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TRANSACTIONS

OF THE

ILLUMINATING ENGINEERING SOCIETY

VOL. XIV
JANUARY-DECEMBER
1919

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ILLUMINATING ENGINEERING SOCIETY
29 WEST THIRTY-NINTH STREET
NEW YORK, N. Y.

(ISSUED DEC. 30, 1919)

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ILLUMINATING ENGINEERING SOCIETY

[Founded in 1906 for the Promotion of the Science and Art of Illumination.]

GENERAL OFFICES: 29 West 39th Street, New York, N. Y.

SECTIONS

Chicago Section

CHAIRMAN . . . . A. O. Dicker, 105 South LaSalle Street, Chicago, Ill.
SECRETARY . . . . E. D. Tillson, 28 North Market Street, Chicago, Ill

MANAGERS

F. F. Fowle . . . . 212 West Washington Street, Chicago, Ill
James J. Kirk . . . . Salineville, Ohio
A. H. Meyer . . . . 431 South Dearborn Street, Chicago, Ill
W. W. Soffe . . . . 522 South Clinton Street, Chicago, Ill
F. A. Watkins . . . . 565 W. Washington St., Chicago, Ill

New England Section

CHAIRMAN . . . . H. F. Wallace, 84 State Street, Boston, Mass
SECRETARY . . . . H. W. Jordan, 39 Boylston Street, Boston, Mass.

MANAGERS

G. N. Chamberlin . . . . 928 Western Avenue, West Lynn, Mass.
John C. D. Clark . . . . 24 West Street, Boston, Mass
Raymond A. Fancy . . . . 308 Washington Street, Newton, Mass.
F. A. Gallagher, Jr. . . . . 814 Turks Head Bldg., Providence, R. I.
A. F. Nelson . . . . 42 Main Street, Brockton, Mass.

New York Section

CHAIRMAN . . . . F. M. Feiker, 36th Street and 10th Avenue, New York, N. Y.
SECRETARY . . . . R. E. Harrington, Fifth and Sussex Streets, Harrison, N. J.

MANAGERS

Wm. J. Clark . . . . 1st Street and 1st Avenue, Mount Vernon, N. Y.
John P. Hanlan . . . . 80 Park Place, Newark, N. J.
L. J. Lewinson . . . . . . 80th Street and East End Avenue, New York, N. Y.
G. W. Magalhaes . . . . 444 Jackson Avenue, Long Island City, N. Y.
John P. Radcliffe, Jr. . . . . 9 Manor House Square, Yonkers, N. Y.

Philadelphia Section

CHAIRMAN . . . . James D. Lee, Jr., 1411 Widener Building, Philadelphia, Pa.
SECRETARY . . . . H. B. Andersen, 1931 South 9th Street, Philadelphia, Pa.

MANAGERS

C. E. Clewell . . . . University of Pennsylvania, Philadelphia, Pa.
Washington Devereux . . . . Bullitt Bldg., Philadelphia, Pa.
R. B. Duncan . . . . 1615 North 9th Street, Philadelphia, Pa.
W. L. Robertson . . . . 1000 Chestnut Street, Philadelphia, Pa.
N. Wiley Thomas . . . . 332 City Hall, Philadelphia, Pa.

LOCAL REPRESENTATIVES

CALIFORNIA:	San Francisco	Romaine W. Myers, [illegible] Bacon Building, Oakland
	Los Angeles	C. M. Masson, Edison Building
CONNECTICUT:	New Haven	Charles F. Scott, Yale University
		J. Arnold Norcross, [illegible] Crown Street
	Hartford	R. E. Simpson, Travelers Insurance Co.
DISTRICT OF COLUMBIA:	Washington	R. B. Patterson, [illegible] 14th Street.
		J. F. Meyer, Bureau of Standards
GEORGIA:	Atlanta	Rawson Collier, Electric and Gas Building
LOUISIANA:	New Orleans	Douglas Anderson, Tulane University of Louisiana.
MASSACHUSETTS:	Springfield	W. E. Hodge, Administration Building.
	Worcester	Carl D. Knight, Worcester Polytechnic Institute.
MICHIGAN:	Detroit	F. R. Mistersky, [illegible] Kenilworth Avenue.
MINNESOTA:	St. Paul	A. L. Abbott, 174 E. 6th Street.
	Minneapolis	G. D. Shepardson, University of Minnesota.
MISSOURI:	St. Louis	H. G. Hake, Washington University.
NEW JERSEY:	Newark	J. N. Adam, Public Service Electric Co.
NEW YORK:	Albany	G. B. Nichols, State Architect's Office.
	Buffalo	F. Park Lewis, 454 Franklin Street.
	Rochester	Frank C. Taylor, 154 Laburnum Crescent.
	Schenectady	S. H. Blake, General Electric Co.
		G. M. J. Mackay, General Electric Co.
	Syracuse	R. A. Porter, 861 Ostrum Avenue.
OHIO:	Cincinnati	A. M. Wilson, University of Cincinnati.
	Cleveland	Ward Harrison, Nela Park.
	Columbus	F. C. Caldwell, Ohio State University.
	Toledo	W. E. Richards, Toledo Railway and Light Co.
OREGON:	Portland	F. H. Murphy, Portland Railway Light and Power Co. Electric Building.
PENNSYLVANIA:	Altoona	J. L. Minick, Room 14, Motive Power Bldg.
RHODE ISLAND:	Providence	F. A. Gallagher, Narragansett Elec. Lighting Co.
TEXAS:	Austin	J. M. Bryant, University of Texas.
UTAH:	Salt Lake City	W. R. Putnam, Utah Power & Light Co.
VIRGINIA:	Charlottesville	W. S. Rodman, University of Virginia.
WASHINGTON:	Seattle	Fred. A. Osborn, University of Washington.
WISCONSIN:	Milwaukee	F. A. Vaughn, 501 Security Building.
CANADA:	Toronto	H. D. Burnett, 212 King Street, W.
	Montreal	L. V. Webber, 285 Beaver Hall Hill.
SOUTH AFRICA:	Johannesburg	H. A. Tinson, South African Gen. Elec. Co., Southern Life Buildings, Transvaal.

OFFICIAL REPRESENTATIVES TO OTHER ORGANIZATIONS

On the United States National Committee of the International Commission on Illumination	Louis Bell, J. R. Cravath, Preston S. Millar.
On American Institute of Electrical Engineers Standards Committee	Clayton H. Sharp.
On Governing Board of the American Association for the Advancement of Science	E. B. Rosa, C. H. Sharp.
On the War Committee of Technical Societies	L. B. Marks, Preston S. Millar.
Assigned to special investigations under National Research Council	H. E. Ives.
On the Advisory Committee, Engineering Division, National Research Council	Edw. P. Hyde.

COMMITTEES—1918-1919.

Except as noted below, all committees are appointed by the President, subject to the approval of the Council, and terminate at the time of the first Council meeting of each new administration, in the month of October. The duties of each committee are indicated.

George A. Hoadley, President, Ex-officio member of all Committees.

(1) STANDING COMMITTEES AUTHORIZED BY THE CONSTITUTION AND BY-LAWS.

COUNCIL EXECUTIVE.—(*Consisting of the President, General Secretary, Treasurer and two members of the Council.*) *Act for the Council between sessions of the latter.*

George A. Hoadley, Chairman.
518 Walnut Lane, Swarthmore, Pa.

Clarence L. Law, L. B. Marks,
Wm. J. Serrill, G. H. Stickney.

FINANCE.—(*Of three members; to continue until successor is appointed.*) *Prepare a budget; approve expenditures; manage the finances; and keep the Council informed on the financial condition.*

Adolph Hertz, Chairman.
Irving Place & 15th St., New York, N. Y.

D. McFarlan Moore, Wm. J. Serrill.

PAPERS.—(*Of at least five members.*) *Provide the program for the annual convention; pass on papers and communications for publication; and provide papers and speakers for joint sessions with other societies.*

G. H. Stickney, Chairman.
Fifth and Sussex Streets, Harrison, N. J.

Chairmen of Section Papers Committees.
C. E. Clewell, Philadelphia.
L. J. Lewinson, New York.
A. H. Meyer, Chicago.
H. F. Wallace, New England.

Members at Large.
C. O. Bond, E. B. Rosa,
E. J. Edwards, P. G. Nutting,
Preston S. Millar, J. D. Israel.

EDITING AND PUBLICATION.—(*Of three members.*) *Edit papers and discussions; and publish the Transactions.*

W. H. Onken, Chairman.
36th St. at 10th Ave., New York, N. Y.
Norman D. Macdonald.

GENERAL BOARD OF EXAMINERS.—(*Appointed by the President.*) *Pass upon the eligibility of applicants for membership, or for change in grade of membership.*

D. McFarlan Moore, Chairman.
Harrison, N. J.

(2) COMMITTEES THAT ARE CUSTOMARILY CONTINUED FROM YEAR TO YEAR.

AUTOMOBILE HEADLIGHTING SPECIFICATIONS.

C. H. Sharp, Chairman.
80th St. and E. End Ave., New York, N.Y.

G. N. Chamberlin, M. W. Hanks,
P. W. Cobb, W. F. Little,
E. C. Crittenden, W. A. McKay.
E. J. Edwards,

EDUCATION.—*Promote the study of subjects relating to illumination in secondary schools and colleges.*

C. E. Clewell, Chairman.
University of Pennsylvania,
Philadelphia, Pa.

W. S. Franklin, Wm. J. Serrill,
H. S. Hower, C. E. Stephens,
C. F. Scott, A. J. Sweet.

LIGHTING LEGISLATION.—*Prepare a digest of laws on illumination, cooperate with other bodies in promoting wise legislation on illumination, and prepare codes of lighting in certain special fields.*

L. B. Marks, Chairman.
103 Park Avenue, New York, N. Y.

W. F. Little, Secretary.
80th St. and E. End Av., New York, N. Y.

W. T. Blackwell, M. Luckiesh,
C. O. Bond, R. H. Maurer,
C. E. Clewell, A. S. McAllister,
C. W. Cutler, G. B. Nichols,
W. A. Durgin, W. J. Serrill,
Ward Harrison, R. E. Simpson,
S. G. Hibben, G. H. Stickney,
J. A. Hoeveler, E. Dean Tanzer,
Clarence L. Law, L. A. Tanzer,
M. G. Lloyd, F. A. Vaughn.

COMMITTEES -- 1918-1919. *(Continued.)*

MEMBERSHIP.—*To act in an Advisory capacity in increasing sustaining membership, membership and associate membership.*

L. J. Lewinson, Chairman.
80th St. & East End Avenue, New York, N. Y.

O. H. Caldwell, E. C. Crittenden, R. A. Fancy, J. H. Fisher, H. S. Hower, O. L. Johnson, M. Luckiesh, W. McKay, H. H. Millar.

NOMENCLATURE AND STANDARDS—*Define the terms and standards of Illumination; and endeavor to obtain uniformity in nomenclature.*

A. E. Kennelly, Chairman.
1 Kennedy Road, Cambridge, Mass.

C. H. Sharp, Secretary.
80th Street & East End Avenue, New York, N. Y.

Louis Bell, C. O. Bond, E. C. Crittenden, W. A. Dorey, E. J. Edwards, E. P. Hyde, C. O. Mailloux, A. S. McAllister, P. G. Nutting, W. E. Saunders, C. P. Steinmetz.

PROGRESS.—*Submit to the annual convention a report on the progress of the year in the science and art of Illumination.*

F. E. Cady, Chairman.
Nela Park, Cleveland, O.

W. B. Lancaster, F. R. Mistersky, T. W. Rolph, W. E. Saunders.

RECIPROCAL RELATIONS WITH OTHER SOCIETIES.—*Promote joint sessions with, or the presentation of Illumination papers, before other societies.*

J. D. Israel, Chairman.
1000 Chestnut St., Philadelphia, Pa.

John C. D. Clark, Wm. A. Durgin, Walton Forstall, Ward Harrison, G. B. Regar, G. H. Stickney.

RESEARCH.—*Stimulate research in the field of Illumination; and keep informed of the progress in research.*

E. B. Rosa, Chairman.
Bureau of Standards, Washington, D. C.

P. W. Cobb, H. C. Crittenden, H. E. Ives, E. F. Kingsbury, R. E. Meyers, G. W. Middlekauff, F. K. Richtmyer, C. H. Sharp, W. B. Weidler.

SUSTAINING MEMBERSHIP.—*Obtain additional Sustaining Members.*

Walter Neumuller, Chairman.
Irving Place & 15th Street, New York, N. Y.

F. R. Barnitz, J. D. Israel, N. D. MacDonald, J. C. McQuiston.

(3) TEMPORARY COMMITTEES FOR SPECIAL PURPOSES. CUSTOMARILY REAPPOINTED BY EACH NEW ADMINISTRATION UNLESS THEIR PURPOSE HAS BEEN FULFILLED.

DIFFUSING MEDIA.—*Study of the phenomena of transmission and reflection of light by various diffusing media, and development and standardization of methods of measurements and test.*

M. Luckiesh, Chairman.
Nela Research Laboratory, Cleveland, Ohio.

E. C. Crittenden, W. F. Little.

POPULAR LECTURES.—*Prepare lectures on selected subjects suitable for presentation to popular audiences.*

R. W. Shenton, Chairman.
Nela Park, Cleveland, O.

N. D. Macdonald, J. H. McGraw, Jr., R. H. Maurer, A. L. Powell.

LECTURES TO ARCHITECTURAL STUDENTS.

Bassett Jones, Chairman.
101 Park Avenue, New York, N. Y.

J. M. Hewlett, Henry Hornbostel, Stepan de Kosenko, M. Luckiesh.

WAR SERVICE.

Executive Committee.

Preston S. Millar, Chairman.
80th Street & East End Avenue, New York, N. Y.

C. W. Cutler, S. E. Doane, W. A. Durgin, Edw. P. Hyde, Clarence L. Law, L. B. Marks, J. F. Meyer, Wm. J. Serrill, G. H. Stickney.

HONOR ROLL.

H. A. Hornor, Chairman.
C102 Hamilton Court, 39th & Chestnut Sts., Philadelphia, Pa.

W. Greeley Hoyt, Otis L. Johnson, Adolph Hertz, Clarence L. Law, H. K. Morrison, C. E. Stephens.

PUBLICITY.

O. H. Caldwell, Chairman.
36th St. at 10th Ave., New York, N. Y.

SKY BRIGHTNESS.

W. F. Little, Chairman.
80th Street & East End Avenue, New York, N. Y.

C. D. Fawcett, H. H. Kimball, L. B. Marks, L. W. Marsh.

REVISION OF THE CONSTITUTION AND BY-LAWS.

G. H. Stickney, Chairman.
Fifth & Sussex Sts., Harrison, N. J.

Clarence L. Law, L. B. Marks, Preston S. Millar, W. D. Weaver.

TIME AND PLACE.

W. Greeley Hoyt, Chairman.

H. A. Hornor, Otis L. Johnson, H. K. Morrison.

TRANSACTIONS

OF THE

Illuminating Engineering Society

PART I -- SOCIETY AFFAIRS

VOL. XIV — FEBRUARY 10, 1919 — No. 1

COUNCIL MINUTES.

ITEMS OF INTEREST.

Meeting—January 9, 1919.

The following applicants were elected to membership, upon the approval of the Board of Examiners:

One Member.

MONTFORD MORRISON
Consulting Engineer,
Victor Electric Corporation,
236 S. Robey St.,
Chicago, Ill.

Three Associate Members.

EMIL HEUSSER
Electrical Engineer,
Professor of Electrical Engineering,
Technikum Winterthur,
Winterthur, Switzerland.

FREDERICK JOSEPH MOSES
Salesman,
The Robert Mitchell Co., Ltd.,
589 St. Catherine St., West,
Montreal, Quebec, Canada.

JOHN H. WATERBURY
Engineering Department,
National Lamp Works,
Nela Park,
Cleveland, Ohio.

Other Changes in Membership.

Three Members Resigned.

M. W. ALLEN
K. G. FRANK
H. E. IVES

Eighteen Associate Members Resigned.

A. R. BEAL
F. H. BOGGIS
J. A. BRITTON
THOMAS COLE
J. T. CALDWELL
W. W. CLOUD
W. P. DEVERY
OTTO FEURLEIN
G. G. FINLEY
K. S. GIBSON
H. M. HAFLEIGH
E. L. MILLIKEN
H. NUSBAUM
D. W. WEAVER
E. WEINTRAUB
N. T. WILCOX
STUART WILDER
K. S. YUEN

The following deaths were reported:

Two Associate Members.

JONATHAN CAMP
Franklin Manufacturing Co.,
Hartford, Conn.

JAMES D. LYNCH
2204 Fairmount Ave.,
Philadelphia, Pa.

Appointments.

The following appointments to committees were confirmed:

Committee on Diffusing Media

E. C. Crittenden
W. F. Little

Committee on Individual Membership:

E. C. Crittenden
H. S. Hower
M. Luckiesh
W. McKay
H. H. Millar
O. H. Caldwell
O. L. Johnson
R. A. Fancy
J. H. Fisher

Committee on Sustaining Membership:

J. D. Israel
J. C. McQuiston
N. D. Macdonald
F. R. Barnitz

Committee on Popular Lectures:

A. L. Powell
N. D. Macdonald
R. H. Maurer
J. H. McGraw, Jr.

Committee on Lighting Legislation:

G. B. Nichols

Committee on Time and Place:

W. Greeley Hoyt, Chairman
H. A. Hornor
Otis L. Johnson
H. K. Morrison

SECTION ACTIVITIES.

NEW YORK.

Meeting—January 9, 1919.

Clifton W. Wilder and Albert E. Allen, Engineers of the Public Service Commission of the City of New York, presented before this meeting the paper entitled "Urban Rapid Transit Car Lighting."

The paper and discussions as presented that evening constitute a part of Part II of this issue.

A survey of the light intensities in hotel rooms was made for the War Service Committee, and by their consent, Wm. F. Little and A. C. Dick presented "Illumination Notes," the second paper of the evening. This paper also appears in Part II of this issue.

NEW ENGLAND.

Meeting—January 7, 1919.

At a joint meeting of the American Institute of Electrical Engineers and the Illuminating Engineering Society, Mr. M. Luckiesh presented "The Principles of Camouflage for Land, Sea and Air." As Chairman of the Committee on Camouflage of the National Research Council, Mr. Luckiesh gave his entire time to the Government in applying camouflage to the conduct of the war. His previous work in light, color, and vision was used to advantage to develop land camouflage for the Army and ship camouflage with the Navy Department.

During extensive investigations on the visibility of airplanes, covering 6,000 miles of actual air travel, Mr. Luckiesh photometered earth and water areas from various altitudes. These photographs, some of them colored, together with the very interesting paper, resulted in a very pleasant evening's entertainment for the members of the New England Section.

PHILADELPHIA.

Meeting—December 20, 1918.

"Fuel Conservation as Affected by Lighting Curtailment" was the paper of the evening, presented by T. C. Mahady,

Fuel Engineer of the Federal Administration of Philadelphia.

Mr. Mahady gave due credit to the Illuminating Engineering Society for its aid to the Fuel Administration in formulating the war regulations adopted by the latter in respect to lighting of all kinds. He intimated that the rules about to be put into effect, when the signing of the armistice intervened, were much more drastic than those previously enforced. His thought is that many of the plans for economy adopted during war time should not be permitted to lapse during peace, but that they should be continued and pushed even harder than before. Our Society has the opportunity of doing valuable work in this direction.

This paper was followed by a few short talks by representatives of the leading department stores on the actual effect on the coal pile, of the Administration's restrictions. The program of the lamp manufacturers was outlined. Talks also were given by representative architects and engineers on the effect on lighting of the arrangement and construction of modern buildings. The general discussion was very interesting.

GENERAL OFFICES.

We are anxious to obtain the present address of Ralph E. Bitner, who formerly resided at 1342 Girard Street, Washington, D. C. Information leading to his present whereabouts may be directed to the General Offices.

NEWS ITEMS.

Purely Personal.

The Associated Press in a disptach from Berlin dated January 10th brought the information that our distinguished fellow-member, Brigadier-General Geo. H. Harries, is head of the American Commission, at that time located at the Hotel Adlon at the corner of Unter den Linden and Pariser Platz. The dispatch stated that a bullet fired during one of the riots struck the casing of a window in General Harries' room without doing any damage.

Major William J. Hammer, member, who in civilian life is a consulting electrical engineer with offices at 55 Liberty Street,, New York City, and who for some time past has served the War Department in the War Plans Division, on December 13th had conferred upon him the honor of being appointed a member of the General Staff Corps. This honor, which Major Hammer greatly deserves, came as a complete surprise to him and is one upon which he is to be congratulated.

D. W. Blakeslee, member, who entered active service as a First Lieutenant, U. S. Army, has returned from a year in France with the 56th Engineers (anti-aircraft searchlights), and is now in the Office of the Chief of Engineers, United States Army.

Some interesting information regarding Major D. C. Jackson, member, was contained in an article in the *Saturday Evening Post* of January 11, 1919, page 35, entitled "Business Managing—War" by Isaac F. Marcasson. According to this writer Major Jackson is the Chief Engineer and active head of the technical board having charge of the procurement of electric power for the A. E. F. This board includes more than 40 American engineers and constitutes a kind of a congress of experts which provides the electric power to drive the Army's many-sided activities.

Presentation of Popular Lectures.

The demand for the presentation of the illustrated popular lectures on "Home, Store and Protective Lighting" is still very great.

Mr. F. A. Vaughn, Local Representative at Milwaukee, Wis., presented before the S. A. T. C. Unit of the School of Engineering of Milwaukee, the popular lecture on "Protective Lighting."

At Salem, Mass., Mr. S. N. Abbott, Official Representative of the Hygrade Lamp Company, is presenting the illustrated lecture on "Home Lighting."

Carl D. Knight, Local Representative for the I. E. S. at Worcester, Mass., presented the popular lecture on "Store Lighting" before the Worcester Electrical Contractors Association and their guests on Wednesday evening, January 22. About 80 were present, including a large delegation from the local section of the N. E. L. A. Much interest was displayed in illumination topics in general.

It is pleasing to note the active interest our Local Representatives are taking to preach good illumination in their communities.

The Edison Pioneers.

Organization of the Men Connected with Thomas A. Edison in Invention and Development Prior to 1886.

An organization was effected in 1918 known as Edison Pioneers, the object of which is to bring together the men who were associated with Thomas A. Edison in his earlier work of invention and experimentation and to perpetuate the memories of those pioneer days. The membership of the Edison Pioneers is limited to persons associated with Mr. Edison or connected with his work prior to and inclusive of the year 1885. The officers of this association are as follows:

President—Francis R. Upton.

Vice-Presidents—S. Z. Mitchell and T. Commerford Martin, Member I. E. S.

Historian—William H. Meadowcroft.

Treasurer—Frederick A. Scheffler.

Secretary—Robert T. Lozier, 32 W. 40th St., New York.

Among the membership, comprising about one hundred persons, are the following well-known electrical men, in addition to the officers named: Dr. Edward G. Acheson, W. S. Andrews, John I. Beggs, C. A. Benton, C. S. Bradley, Col. H. M. Byllesby, Charles L. Edgar, Member I. E. S.; Charles L. Eidlitz, W. E. Gilmore, Edwin T. Greenfield, John W. Howell, Wm. J. Hammer, Member I. E. S.; F. S. Hastings, Samuel Insull, Member I. E. S.; Alfred W. Kiddle, J. W. Lieb, Member I. E. S.; Geo. F. Morrison, Frederic Nicholls, John G. Ott, Charles R. Price, Louis Rau, Frederick Sargent, Charles Wirt, Edwin R. Weeks, and Dr. S. S. Wheeler.

OBITUARY.

Printed below is a copy of the announcement which brought us the news of the death of Lieut. Edward D. Baker (associate member). Lieut. Edward D. Baker was associated with the Roffy-Baker Company of Pittsburgh, Pa.

"The tumult and the shouting dies.
  The captains and the kings depart.
Still stands our ancient sacrifice,
  An humble and a contrite heart."

Lieut. Edward D. Baker; pilot in air service.

Born Oct. 15, 1896—Volunteered May 10, 1917.

God summoned him while in battle and he met his pilot face to face October 24, 1918.

He sleeps at Souilly-Meuse, in France.

Edward was with us just a while—a noble soul, our son and only child.

Freedom and Righteousness in distress called to him and he freely offered all.

The sympathy and gracious messages of our dear friends bear the warmth of God's love when the heart is weary.

MR. and MRS. SIMON STROUSSE BAKER.

ILLUMINATION INDEX.

Prepared by the Committee on Progress.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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Monthly Abstract Bulletin, Research Laboratory, Eastman Kodak Co.			
Germicidal Action of Ultra-Violet Radiation (Appeared in Archives Rad. and Elect., Aug., 1918, p. 85)—	C. H. Browning and S. Russ	Dec.	
Popular Mechanics			
New Light for Safety Island Urged by Government—	News Item	Dec.	910

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Perfectionnements dans les lampes électriques à arc (Abstract, p. 136D)—		Oct. 26	
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TRANSACTIONS

OF THE

Illuminating Engineering Society

PART I -- SOCIETY AFFAIRS

VOL. XIV | MARCH 20, 1919 | No. 2

COUNCIL MINUTES.

ITEMS OF INTEREST.

Meeting—February 13, 1919.

Appointment of Director.

To fill the vacancy caused by the death of Robert ffrench Pierce, President Hoadley appointed Adolph Hertz, Director, for the term ending September 30, 1920. Mr. Hertz has served the Society for a number of years chiefly as a member or chairman of the Committee on Finance.

Upon recommendation of the Board of Examiners the following were elected to membership:

One Transfer.

ADOLPH HERTZ
Statistician,
The New York Edison Co.,
Irving Place and 15th St.,
New York, N. Y.

Four Members.

PERCY HODGE
Professor of Physics,
Stevens Institute of Technology,
Hoboken, N. J.

CAPTAIN H. J. HOWARD
Ophthalmologist,
106 Tenth St.,
Garden City, N. Y.

OTHO M. OTTE
Illuminating Engineer,
Interior Metal Mfg. Co.,
Jamestown, N. Y.

ABRAHAM SHOHAN
Electrical Engineer,
Public Works Dept.,
Navy Yard,
Boston, Mass.

Six Associate Members.

EDWARD L. BRADBURY
Salesman, Ivanhoe Regent Works,
105 W. 40th St.,
New York, N. Y.

A. C. DICK
Electrical Testing Laboratories,
80th St. and East End Ave.,
New York, N. Y.

FRANK E. JONES
Secretary and Sales Manager,
The Strong Manufacturing Co.,
Sebring, Ohio.

KENNETH W. MACKALL
Crouse Hinds Co.,
Syracuse, N. Y.

ARCHIBALD L. SHAW
Engineer,
Apartment 17, 1 Alpine St.,
Newark, N. J.

MABEL H. TAYLOR
Technical Work,
Electrical Testing Laboratories,
80th St. and East End Ave.,
New York, N. Y.

Committee Report.

Mr. L. B. Marks, Chairman of the Committee on Lighting Legislation, presented to Council a draft covering the provisions of a model headlight law which were discussed from various angles by the members of the Committee on Lighting Legislation in conference with the Committee on Automobile Headlighting Specifications, and by representatives of the Society of Automotive Engineers, the American Automobile Association, and other bodies directly interested in this subject. Council has approved the plan to distribute these proposed regulations at once to legislators and others interested in the enactment and amendment of headlight laws in many of the states, the legislatures of which are now in session.

SECTION ACTIVITIES.

PHILADELPHIA.

Meeting—January 13, 1919.

The monthly meeting of the Philadelphia Section took the form of a joint session with the Philadelphia Section of the American Institute of Electrical Engineers, and was held in the auditorium of the Engineers Club of Philadelphia.

The meeting was opened by Mr. William F. James, Chairman of the Philadelphia Section, American Institute of Electrical Engineers, and was turned over by him to Mr. James D. Lee, Jr., Chairman of the Philadelphia Section, Illuminating Engineering Society.

The paper of the evening was presented by Mr. Norman D. Macdonald, representing Mr. Preston S. Millar, who was unable to attend because of illness. The subject was "Wartime Lighting." Mr. Macdonald dwelt on the practical and psychological effects of the various regulations of illumination that were adopted, and gave many illustrations to show that the work of the Illuminating Engineering Society, and of its members who were active in various committee work, was of great benefit to and greatly appreciated by the Government. An interesting discussion of the paper took place, after the meeting was adjourned and light refreshments served. The meeting was well attended.

Meeting—February 6, 1919.

The Franklin Institute and the Philadelphia Section of the I. E. S. met in a joint session in the lecture hall of the Institute.

The paper of the evening was presented by Professor C. E. Clewell, on "Industrial Lighting." It dealt in an especially interesting and non-technical manner with the necessity of improving lighting used in industrial operations, and with the ways in which this is easily and economically possible. A large number of the slides were exhibited, also the latest type of photometer, which is light and compact, and can be used to demonstrate to the layman the relative amounts of illumination at the various points which are being investigated.

NEW ENGLAND.

Meeting—February 18, 1919.

"Wartime Lighting" was presented by Preston S. Millar, and discussed by members of the Section. The meeting was enthusiastic and well attended.

NEW YORK.

Meeting—February 13, 1919.

The "Lighting of Shipyards" and "Wartime Lighting" were the papers of the evening, presented by H. A. Hornor and Preston S. Millar respectively.

CHICAGO.

Meeting—February 20, 1919.

Mr. Wm. A. Durgin presented "Lighting for Production." Starting with a model demonstrating by light itself, the effect of several plans of natural and artificial lighting on the working plane in a large factory, Mr. Durgin presented industrial lighting from the viewpoints of factory manager, efficiency engineer, and wiring contractor, as well as of the user. Desirable and undesirable characteristics of the several classes of units now available were shown, and some new selling arguments developed. About one hundred and fifty members and guests attended the meeting.

The next meeting will be held on March 20, at which time Mr. S. E. Doane will address the Section. Mr. G. H. Stickney will present "Industrial Lighting Codes" before the Section on April 17.

NEWS ITEM.

Presentation of Popular Lectures.

Before the State Normal School and Training School of Salem, Mass., there were presented the two popular lectures on "The Lighting of the Home" and "Protective Lighting."

We learn from W. G. Whitman, Editor of the *General Science Quarterly*, who presented these lectures that they were the means of stimulating much interest in the subjects of home and protective lighting. Mr. Whitman also exhibited these slides at a meeting of general science teachers in Boston, where the good features of the slides and lectures were of real value in educational work.

Personal.

L. C. Porter, who enlisted and received a commission as Lieutenant assigned to the Naval Experimental Station at New London, Conn., has returned to resume civil work and is now connected with the Edison Lamp Works at Harrison, N. J.

A new addition to the TRANSACTIONS by the Committee on Progress will be found under the title "Books" immediately following "Illumination Index."

From time to time this contribution by the Committee on Progress will appear in order to acquaint readers of the TRANSACTIONS with new books by authors who deal with the importance of proper illumination in relation to health, conservation of vision, industrial progress, industrial accidents, and with all other phases of illuminating engineering.

GENERAL OFFICE.

We are anxious to learn the present whereabouts of Mr. Frank Fisher, formerly Director of the Citizens Electric Company at Williamsport, Pa. Address information to the General Office.

OBITUARY.

News has reached the General Office of the deaths of Thos. S. Genay, formerly of the United Gas Improvement Co. at Philadelphia, Pa.; David R. Daly, up to the time of his death connected with J. H. Gautier & Co.; and J. P. Stone, who was connected with Lindeteves, New York.

At his home in Oak Park, Ill., on February 15, 1919, Alfred O. Dicker passed away, a victim of pneumonia. From October 1, 1918, up to the time of his death, Mr. Dicker was Chairman of the Chicago Section. He was an earnest worker of the Society, and without a doubt his loss will be keenly felt.

Mr. Dicker was born in Chicago, January 8, 1889; graduate of the University of Michigan, class 1911, and a member of the Beta Theta Pi Fraternity. At the time of his death he was Chicago Representative of the St. Louis Brass Company and Luminous Unit Company.

His wife and daughter survive him.

The Society was represented at the funeral by a delegation of the Chicago Section members.

ILLUMINATION INDEX.

Prepared by the Committee on Progress.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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BOOKS.

HYGIENE OF THE EYE—Wm. Campbell Posey, A. B., M. D. Published by J. B. Lippincott Co., Philadelphia and London; 344 pages, numerous illustrations; price $4.00 net.

Through the courtesy of the author and publishers a copy of the above book has been received. It treats of the subject, principally from the medical standpoint, in popularly understandable terms. It contains a chapter on Artificial Lighting by Dr. H. E. Ives.

THE RESULTS OF MUNICIPAL ELECTRIC LIGHTING IN MASSACHUSETTS—Edmond Earle Lincoln, M. A., Ph. D. Published by Houghton Mifflin Co., Boston and New York; 484 pages, numerous tables and curves; price $3.00 net.

An economic study of municipal lighting by publicly and privately owned plants based largely on the records of the Massachusetts Board of Gas and Electric Light Commissioners. There is no direct reference to illuminating engineering features.

WORKS LIGHTING—Daniel H. Ogley, B. Eng. Published by Iliffe & Sons, Ltd., London; 146 pages, with tables, illustrations and photometric curves of electric and gas lamps and lighting; price $2.75 net.

A popular book on the lighting of industrial plants with particular reference to British practice. Treats of desirability of good illumination, measurement of illumination, natural lighting, also electric, gas and oil lighting.

TRANSACTIONS

OF THE

Illuminating Engineering Society

PART I -- SOCIETY AFFAIRS

VOL. XIV APRIL 30, 1919 No. 3

COUNCIL NOTES.

ITEMS OF INTEREST.

New Members.

Upon recommendation of the Board of Examiners, the following were elected to membership:

Four Members.

L. LeRoy Gritzan
Illuminating Engineer,
Standard Elec. & Elev. Co., Inc.,
118 E. Pratt St.,
Baltimore, Md.

Edward A. Guay
Superintendent,
Edison Lamp Works of General Electric Co.,
156 Porter St.,
East Boston, Mass.

Frederick Shannon Mills
Engineer,
National X-Ray Reflector Co.,
742 Market St.,
San Francisco, Cal.

Prescott B. Wiske
Acting Manager, Commercial Dept.,
The Brooklyn-Union Gas Co.,
176 Remsen St.,
Brooklyn, N. Y.

Eight Associate Members.

Arthur J. Becker
Consulting and Contracting Electrical Engineer,
222 Hudson Ave.,
Rochester, N. Y.

Clarence J. Berry
Electrical Engineer,
National Lamp Works of General Electric Co.,
Nela Park,
Cleveland, Ohio.

R. J. Johnston
Electrical Engineer,
Navy Department,
17th and B Sts., N. W.,
Washington, D. C.

Henry Logan
Architect and Illuminating Engineer,
L. Sonneborn & Sons,
262 Pearl St.,
New York, N. Y.

Arthur Graham Plumpton
Photometric Laboratory Assistant,
Hydro-Electric Power Commission of Ontario,
8 Stracham Ave.,
Toronto, Ontario, Canada.

Robin G. Gray
Supervisor of Buildings,
Bell Telephone Co. of Canada,
Montreal, Canada.

Frank D. Tansey
Supervisor, Lighting Division,
The Brooklyn United Gas Co.,
180 Remsen St.,
Brooklyn, N. Y.

Wm. Orford Taylor
Specialist in Charge,
General Lighting Dept.,
Northern Electric Co., Ltd.,
121 Shearer St.,
Montreal, Canada.

SECTION ACTIVITIES

PHILADELPHIA.

Meeting—March 21, 1919.

The monthly meeting of the Philadelphia Section was held on March 21, 1919, at 8 p. m., at the Engineers' Club of Philadelphia, 1317 Spruce Street. The paper of the evening, "Transmission of Colored Light Through Fog" by Professor C. L. Utterback, of the University of Washington State, was presented by Professor Thos. D. Cope, Ph. D., of the University of Pennsylvania. Dr. Cope discussed the paper from the standpoint of comparative results obtained by other investigators, and explained the significance of these various results as applied to practice. The interesting discussion which followed was participated in by the representatives of the professions and trades which have to deal with the problem of transmitting colored light through fog. Considerable difference of opinion was evidenced about the practical value of the results reported by the different experimenters.

A well attended dinner preceded the meeting.

NEW YORK.

Meeting—March 20, 1919.

"Transmission of Colored Light Through Fog" by C. L. Utterback, and "Some Experiments on the Eye with Different Illuminants" (Part II) by C. E. Ferree and G. Rand, were the papers of the evening.

Due to the absence of Prof. Utterback of the Washington State University, Seattle, Wash., Mr. L. C. Porter read Prof. Utterback's paper.

Dr. Ferree presented an outline of the method of making his tests, before presenting his paper. This paper elicited considerable discussion as to the method of the test and results arrived at.

The usual dinner gathering preceded the meeting.

CHICAGO.

Meeting—March 20, 1919.

"Lighting Opportunities During Reconstruction" was presented by Mr. S. E. Doane, of Cleveland, Ohio.

Mr. Doane stated that this title was chosen for him and was not what he would have selected of his own accord; that nothing has been broken down in this country and therefore there was nothing to reconstruct. However, there were, in his opinion, great opportunities for lighting in America for the next few years, principally as improving the status and endeavor of those engaged in the industries.

One of the most important preliminaries to the universal acceptance of high lighting standard was a wide-spread knowledge of the units of illumination, particularly the foot-candle unit, and Mr. Doane exhibited a large sized model of the foot-candle meter, also one of the commercial instruments, and explained its use and the manner in which he believed this would spread the knowledge of illumination principles. Mr. Doane also distributed copies of the proposed factory lighting code for

Ohio and called attention to its provisions.

There was no formal discussion, but a sort of a round table was formed, in which those present aired their views on the subject.

On April 17th Mr. G. H. Stickney of Harrison, N. J., will present "Present Status of Industrial Lighting Codes."

NEW ENGLAND.

Meeting—April 2, 1919.

At the Boston City Club, Boston, Mass., members of the New England Section were invited to attend the Tenth Annual Engineers' Dinner. Hon. George H. Moses, U. S. Senator from New Hampshire, discussed "A League of Nations." "Reflection Suggested from a Recent Trip to France" was delivered by Prof. George Fillamore Swain, of Harvard University.

NEWS ITEMS.

Joint Meeting of the A. I. E. E. and I. E. S.

A joint meeting of the A. I. E. E. and I. E. S. was held on Friday evening, April 11th, in New York, at which time lighting codes formed the topic of discussion. Mr. G. H. Stickney, Past President I. E. S., presented "Present Status of Industrial Lighting Codes." The paper and discussions will appear in the next issue of the TRANSACTIONS.

Subsequent to the New York meeting, Mr. Stickney presented this paper before a joint meeting of the A. I. E. E. and I. E. S. in Chicago and Boston on April 17th and April 22nd respectively.

Oregon Industrial Lighting Code.

Oregon has been added to the states in which a code of lighting has been put into effect by legislative enactment. A bill enacting such a code into law was signed by the Governor in February, 1919. The law is divided into nine sections as follows:

Section I relates to the construction to be placed upon the terms used in the act. According to this construction the scope of the law is apparently wider than that in any other state and covers every place in which work is done "whether indoors or out, or underground * * * where any person is directly or indirectly employed by another," except "where persons are employed in private domestic service or agricultural pursuits which do not involve the use of mechanical power."

Sections II and III are the same as subdivisions 3 and 4 of Section 81 of the present New York State law relating to the lighting of passageways, halls, stairways and workrooms.

Section IV prescribes that all "working or traversed spaces * * * shall be supplied during the time of use with artificial light in accordance with a schedule of minimum values" when natural light falls below these minima.

Section V states that "lamps must be so located or suitably shaded as to minimize glare."

Sections VI and VII relate to distribution of light, emergency lighting and switching and controlling apparatus, and are identical with regulations laid down in the I. E. S. code.

Section VIII authorizes the Commissioner of Labor and Inspector of Factories and Workshops of the State of Oregon "to establish certain minimum values for lighting" (referred to in Section IV above) and stipulates that "In arriving at what values shall be used in this schedule of minimum lighting, and such other rules as shall determine definitely what shall constitute

compliance with the provisions of this act, the Commissioner of Labor shall be guided by the best engineering practice as set forth in the recommendations of the Illuminating Engineering Society." It is further stipulated that before such schedule and rules shall become effective, public hearings thereon must be held and they must receive the approval of a special commission of three members appointed by the Commissioner of Labor for this purpose. The function of this commission is substantially the same as that of the Industrial Board of the Department of Labor in some other states in which the code has been adopted.

Section IX makes it a misdemeanor to violate the provisions of this act and provides penalties for such violation.

In the preparation of this lighting code and in the steps leading to its legislative enactment, the Oregon state authorities had the co-operation of the Divisional Lighting Committee of the Committee on Labor, Council of National Defense and also of the Illuminating Engineering Society, both of which were represented by Mr. F. H. Murphy of Portland.

A series of meetings was arranged for by the Illumination Committee of the Ohio Electric Light Association, Greenville, Ohio. The meetings were held at Columbus, Ohio, on April 9th; April 10th at Toledo, Ohio, and on April 11th at Akron, Ohio.

Mr. H. H. Magdsick, member I. E. S., presented "Illumination Design;" Mr. W. E. Richards, Local Representative I. E. S. at Toledo, Ohio, delivered an address on "Industrial Illumination;" Prof. F. C. Caldwell, of the Ohio State University and member I. E. S., presented "Illumination Measurements."

COMMITTEE ACTIVITIES.

Individual Membership.

The Committee on Individual Membership is at the present time acting largely as a clearing house for ideas received from the various local membership committees. An attempt has been made to secure new members through a form of prospect card, 300 of which were sent to prominent members of the Society.

The New York Section expects to organize a whirlwind campaign to secure fifty members during the second week in April. The results of this campaign no doubt will be of interest to other Sections.

The committee is co-operating with the General Office in an attempt to retain the present membership of the Society. Letters to delinquent members have been issued by the committee, pointing out the importance of remitting dues which are in arrears.

Reciprocal Relations with Other Societies.

The committee has again started its propaganda work which had necessarily been hampered by the war. The restrictions on time, etc., are still evident, however, and the committee is endeavoring to encourage the Sections in holding joint meetings with other societies, realizing that this conservation has the two-fold effect in saving time, and also acquainting each other with the work the societies are accomplishing.

With this same conservative spirit the committee has approached the main bodies of a number of the technical societies, and in each case received encouraging responses.

Arrangements have already been made to have Mr. W. D'A. Ryan present a paper at the coming convention of the American Society for Municipal Improvement.

Co-operation.

Engineering Council has passed a resolution advocating the creation by Congress of a Department of Public Works and urging all members of the engineering profession in all branches to participate in an effort to acquaint the people of the country with the critical importance of this matter and to assist in the creation of such a department.

The principle underlying the foregoing has been urged during the last half century by many engineers, but no legislative result has ever been achieved. The need for a Department of Public Works has now become so urgent that the project is being advocated throughout the whole country. Immediate action by engineers is desirable so that a well considered plan, which will receive unanimous engineering support, may be laid before the 66th Congress.

The Illuminating Engineering Society has been invited to send a delegate to attend the meeting of the Engineering Council scheduled for April 23rd to 25th, at Chicago, Ill., and at the last meeting of the Council Mr. F. A. Vaughn, Local Representative at Milwaukee, Wis., was appointed.

Woman in Industry Service, a department recently created by the U. S. Department of Labor, called upon the Society for the loan of photographs used in our Code of Lighting Factories, Mills and Other Work Places.

The department is making a special study of health conditions surrounding women in industrial establishments. The questions of fatigue, conservation of vision, relation of proper illumination to health, are all considered and to illustrate the desirability of ideal working conditions, the department is planning exhibits all over the country.

The Industrial Accident Commission of California is preparing a set of General Lighting Safety Orders, applicable throughout the state, and has called upon the I. E. S. for the use of the cuts illustrating our Code of Lighting Factories, Mills and Other Work Places, which will be embodied in the General Lighting Safety Orders for the State of California.

Presentation of Popular Lectures.

At Houghton, Mich., before the Houghton Public Schools, A. O. Goodale, Superintendent, presented the illustrated popular lecture on "The Lighting of the Home."

From Mr. Goodale we learn that the lecture afforded interest to the students and all others present.

Unusual interest and demand has been displayed in the lectures on the "Lighting of the Home," "Store Lighting" and "Protective Lighting." From the New England States to Portland, Ore., requests have been received for the privilege of presenting these lectures.

For the March 28th meeting of the Electric Club of Buffalo, it was found advantageous for the educational program of that meeting to present the popular lecture on "The Lighting of the Home."

Before the Chelmsford High School, Chelmsford, Mass., the lecture on "Protective Lighting" was presented.

Mr. H. D. Burnett, Local Representative at Toronto, Canada, arranged for the presentation of the lecture on "Store Lighting," before the recently founded club of Engineers of Toronto. The meeting was held on April 8th and as Mr. Burnett expresses it he is in "hopes that it will bear good fruit in the effort to correct some of the many abuses of good lighting prevalent in Toronto stores."

Toronto, Ont.

On May 16th, Mr. M. Luckiesh has been invited to deliver a lecture on some aspect of illuminating engineering, before a joint meeting of the A. I. E. E. members and members of the I. E. S. residing in Toronto, Ont.

Members of the recently organized club of engineers interested in improving lighting conditions in Toronto, have also been invited to attend this joint session.

Personal.

J. N. Adam, after serving in the New Business Department of the Public Service Electric Co. of New Jersey for nine years, has tendered his resignation to become associated with S. C. Schrenck, Eastern manager for the Belden Manufacturing Co., of Chicago, as well as the southeastern section of the Atlantic seaboard. During his association with the New Jersey company, Mr. Adam was prominent in the various activities of the company as well as an active member of the Illuminating Engineering Society. He has served on various committees of the Society and has for the past six years been a Local Representative for New Jersey.

D. W. Blakeslee, Electrical Engineer, formerly Assistant Superintendent of the Penn Electrical & Manufacturing Co., has, after having served in the Engineers, United States Army, returned to his civil occupation with the Jones & Laughlin Steel Co., Pittsburgh, Pa.

Mr. Blakeslee held his commission as First Lieutenant for about two years. During his year in France he acted as Company Commander for Co. A and Co. C, 56th Engineers, after which he did the scientific experimental and development work of the A. E. F. in connection with anti-aircraft searchlights and single station sound ranging applications. Since returning to the United States he had been stationed in the Office of the Chief of Engineers, Washington, D. C.

Mr. Blakeslee makes a specialty of mill and factory lighting and power applications. He is a member of the American Institute of Electrical Engineers, the Illuminating Engineering Society, the American Electrochemical Society, the Society for the Promotion of Engineering Education, the American Association for the Advancement of Science, and the American Metric Association.

J. L. Stair, Chief Engineer of the National X-Ray Reflector Company of Chicago, gave an illustrated talk on the "Art of Lighting" at the regular monthly meeting of the Springfield Engineers Club, Springfield, Ill., Friday, March 14th.

The meeting was well attended by the members of the club and also by architects of that city. After a general discussion of the various aspects of modern lighting, special emphasis was placed upon illumination of interiors without the use of ceiling fixtures, as one of the latest developments in lighting.

The principal talk of the evening was illustrated by a large number of lantern

slides, supplemented by a demonstration in color lighting and was followed by an explanation in simple terms of how light is measured. The fundamental principles of the photometer were made plain by a candle and grease spot demonstration.

CONVENTION.

There will be a three-day convention of the Society held in Chicago the second or third week of October. Chicago was decided upon as the convention city for this year as a result of an invitation extended by the Chicago Section.

The Committee on Papers has started to prepare the papers program and will be very glad to receive suggestions from the membership as to available papers or interesting topics to be discussed.

GENERAL OFFICE.

Some of our members are still in arrears on their dues for the present fiscal year. One of our active members suggests we insert the following:

"The Illuminating Engineering Society absorbs its income in the diffusion of light on lighting, so please duly reflect and transmit your dues to the General Office."

OBITUARY.

On March 27, 1919, George M. Okie, associate member, I. E. S., and representative of the Macbeth-Evans Glass Company, New York, passed away.

ILLUMINATION INDEX.

Prepared by the Committee on Progress.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

		DATE	PAGE
Journal of Industrial and Engineering Chemistry			
A New Illuminator for Microscopes—	A. Silverman	Dec. 1	1013
Electric Lamp Industry in France—	News Item	Dec. 1	1021
Journal of Physical Chemistry			
The Color of Colloids, II—	Wilder D. Bancroft	Jan.	1
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TRANSACTIONS

OF THE

Illuminating Engineering Society

PART I -- SOCIETY AFFAIRS

VOL. XIV | JUNE 10. 1919 | No. 4

COUNCIL NOTES.

ITEMS OF INTEREST FROM THE COUNCIL MEETING HELD ON MAY 8, 1919.

Purchase of Bond of the Fifth Liberty Loan.

Council approved the recommendation of the Committee on Finance and ordered the purchase of a $500 bond of the Fifth Liberty Loan.

Upon the recommendation of the Board of Examiners, the following were elected to membership:

One Member.

WILLIAM M. GOODRICH
Western Electric Co., Inc.,
500 S. Clinton St.,
Chicago, Ill.

Three Associate Members.

R. M. GRAVES
Testing Engineer,
Commonwealth Edison Co.,
28 N. Market St.,
Chicago, Ill.

LOUIS A. M. PHELAN
Electrical Tester,
Commonwealth Edison Co.,
28 N. Market St.,
Chicago, Ill.

WILLIAM M. CRANE
President, William M. Crane Co.,
16 W. 32nd St.,
New York, N. Y.

SECTION ACTIVITIES.

PHILADELPHIA.

Meeting—April 23, 1919.

The monthly meeting of the Philadelphia Section was held on April 23, 1919, at 8 p. m., in the Auditorium of the Engineers' Club, 1317 Spruce Street. The paper of the evening, "Some Practical Measurements of Daylight in Modern Factory Buildings," was presented by Mr. E. G. Perrot. It dealt with the results obtained by him in a large number of measurements taken inside and outside of several buildings of various types. The effect was shown, of time of day and year, of floor height, of interior construction, and of other variable features, on the illumination afforded by daylight in various parts of the building. The data obtained all show the great importance, when designing a building, of giving consideration to certain features, if the most desirable results from daylight are to be obtained. Among the factors to be considered in this design are the effect on the workers, and the critical point

at which the loss of heat, due to increased window area, will exceed the gain due to increased natural illumination. The paper was illustrated with lantern slides. An interesting discussion followed its presentation.

The regular dinner preceding the meeting was held at the Engineers' Club.

Meeting—May 16, 1919.

The monthly meeting of the Philadelphia Section was held on May 16th, at 8 p. m., in the Auditorium of the Engineers' Club, 1317 Spruce Street. Dr. George A. Hoadley presented a paper, "The Relation of the Illuminating Engineering Society to its Members," and told in it of the advantages which the Society presents to its members, one of the foremost being the educational features of broad and of the specific interest. Mr. Preston S. Millar talked of "The Prospects and Possibilities of the Future." He stated the many reasons why he is interested in the Society, and showed that a local section can be of more value to itself and to the community, if it sets out to attain some definite accomplishment. There are a number of such accomplishments which would be of mutual benefit both to the community and the Society. The meeting adjourned after an interesting discussion, in which many helpful ideas were advanced for the next year's work.

CHICAGO.

Meeting—April 17, 1919.

Mr. G. H. Stickney presented "Present Status of Industrial Lighting Codes" before a meeting of the Chicago Section on April 17th. The meeting was a joint meeting of the Chicago Section of the A. I. E. E. and the I. E. S. The discussion was entered into by Messrs. Hoeveler, Bowman, Stair, Cravath, Steifens, Bernhard and Tillson. Mr. Hoeveler dwelt at some length on the reception which the Wisconsin Code encountered among the industries and the public in general. The others covered points of separate emergency circuits, the difficulty of specifying glare effects in factory codes, the necessity for the adoption of a code for the State of Illinois, and the practicability of a portable foot-candle meter. These discussions appear in Part II of this issue.

NEW ENGLAND.

Meeting—April 22, 1919.

Before the meeting of the Boston Section of the A. I. E. E. held in conjunction with the New England Section of the I. E. S., Mr. G. H. Stickney presented "Present Status of Industrial Lighting Codes" on April 22nd.

The paper was very enthusiastically received, and there was considerable discussion. The paper and discussions appear in Part II of this issue.

NEW YORK.

Meeting—May 8, 1919.

The May meeting of the New York Section was the last meeting of the Section for the present year and it was agreed by all to have been a complete success.

The meeting was preceded by an informal table de'hote dinner at the Café Boulevard. During the dinner vocal selections were rendered by a quartette of the Gas and Electric Choral Society. Directly after the dinner Capt. Logan (associate member), Field Artillery, U. S. A., gave an interesting talk on "How the Artillery Fights."

"Marine Camouflage" was the subject of the evening's meeting held at the

Engineering Societies Building. Lieut Van Buskirk, Construction Corps, U. S. N. R. F., talked on the "Growth of Marine Camouflage." The subject of Lieut. Warner's paper was the "Science of Marine Camouflage Design," while Dr. Loyd A. Jones talked on the "Low Visibility Phase of Marine Camouflage."

The speakers illustrated their papers by means of many lantern slides which were both interesting and instructive.

NEWS ITEMS.

The I. E. S. Transactions Appreciated Abroad.

That the papers in our TRANSACTIONS are being read and appreciated abroad is shown in a recent paper by an illuminating engineer in Holland, published in the Viennese journal *Elektrotechnik und Maschinenbau* on "Determining the Mean Spherical Candlepower." In it he four times cites references to papers in our TRANSACTIONS.

Concerning the rather wide departure from Lambert's law in the vacuum and gas-filled lamps with spiral filaments, he refers to Fig. 4 in Vol. 11, 1916, p. 187. In referring to the proper angular spacing for obtaining the mean from a distribution curve, he cites the paper by Cravath and Lansingh, Vol. 3, 1908, p. 518. The angles for measuring the proper mean are reproduced from the paper of Rolph, Vol. 3, 1908, p. 351. He refers also to the appropriately ruled polar diagram paper of our member Norman Macbeth, described in the *Illuminating Engineer*, Vol. 5, 1910, p. 126, which he announces is now being made and introduced by a local dealer.

The main portion of his paper consists of an abstract, discussion and amplification of the paper by Hering, Vol. 4, 1909, p. 354, on "Measuring Spherical Candlepower by Averaging, the Equal Subdivision of the Sphere." He refers to it as the "very noteworthy work" of that author, adding that "like many other similar pieces of work it did not receive the attention in Europe which it deserves." He refers a number of times to what he acknowledges a new law, calling it "Hering's law," adding a mathematical proof of it, and confirming its theoretical correctness. He credits the author with having been the first to determine with mathematical accuracy certain "characteristic" angles of which he says only approximate empirical values had been used before. He favors Hering's method of studying the proper measurement of the spherical candlepower by using the subdivisions of the sphere as a basis.

Co-operation.

The Industrial Accident Commission of the State of California has issued Tentative General Lighting Safety Orders. Reference to the issuance of such a pamphlet was made in the preceding number of the TRANSACTIONS.

Of noteworthy interest in connection with the Tentative General Lighting Safety Orders is the acknowledgment made therein of the assistance rendered by the Illuminating Engineering Society in the preparation of these Tentative Orders, and for the use of the various cuts which were loaned.

News of the Society's work in the promulgation of industrial codes, factory lighting, lighting economies and prevention of accident hazards has reached the distant shores of Sweden.

Recently a government official of the Swedish Government called at the General Offices in quest of information and data the Society has published covering all phases of factory lighting.

The Government of Sweden is anxious to establish a national industrial code, and all information available in Europe, according to the representative, pointed to the fact that the Illuminating Engineering Society of America was the leading factor in the preparation of industrial codes.

Engineering Council Announces a National Legislative and Departmental Information Service for Engineers in All Branches of the Profession.

This service has been placed under engineering direction, so that responses to inquiries will be specific and suitable for engineering use. Engineering Council has established this service in response to frequent expressions of need. Its continuance will depend largely on its use by the engineers of the country. No charge will be made for such services as the committee can render.

The Statistical, Research and Construction Bureaus of the Government have become valuable sources of engineering information, but have not been used by engineers to the extent merited by the character of their material. Many matters before Congress involve engineering considerations, of which members of the profession should be aware.

Set forth in specific language the kind of information wanted.

Address the National Service Committee, M. O. Leighton, Chairman, 502 McLachlen Building, Washington, D. C.

Help Him Forget.

Upon the manner in which the wounded soldier spends the period of his convalescence in a military hospital may depend his entire future career. In those months directly preceding his reentrance into the industrial world, he is likely to form a habit of mind which will manifest itself in his business life. Educators have long realized the importance of spending leisure wisely and the necessity of healthful influences for our convalescent service men is a matter involving not only the welfare of the individual, but the general interest of society, in the broadest sense of the word.

Desiring to repay, in just one more way, the nation's debt to the fighting men and at the same time to raise social standards, the Red Cross has enlisted some of the best educational minds in the country in devising an organized recreational program for the men in the Government hospitals throughout the United States. In the old order of things, institutional life was a depressing environment, its hard and fast discipline breeding discontent and stifling initiative. Under the new regime, so varied are the activities provided, that every man has ample opportunity to spend his time in a manner both profitable and enjoyable with the result that discipline can be reduced to the minimum.

As the Government has provided the best surgical skill and medical care for his physical welfare so the Red Cross is offering to him the most intelligent guidance for his leisure.

Dr. Albert K. Fretwell, head of the Department of Recreational Leadership of Teachers' College, Columbia University, has made a tour of the reconstruction hospitals, traveling under the joint direction of the Surgeon General's Office and under the Bureau of Camp Service, Department of Military Relief of the Red Cross. The Surgeon General has requested commanding officers to expedite the work by all means possible.

The Red Cross is furnishing equipment for sports and games of all sorts, facilities for music and reading and securing trained personnel for leadership. The Red Cross recreation house attached to the hospital is in reality an up-to-date club possessing all the advantages of the establishment with a waiting membership list. There is a library including technical works as well as fiction and current magazines. Music has been encouraged, and many of the hospitals now boast an orchestra, the instruments having been furnished by the Red Cross, which has also secured professional musicians to coach the boys. All sorts of entertainments are arranged, ranging in character from the purely sociable dance to educational lectures and motion pictures. For patients who are bed-ridden, all of these entertainments are provided, in modified form or to the extent feasible and advisable. Even the movies are brought to the wards, for in some hospitals a special machine has been installed whereby pictures are thrown on the ceiling.

No recreational program which did not make ample provision for sports could be expected to kindle much enthusiasm among our vigorous, hard-fighting young men, even though they are not able to participate in them to any marked extent. The ones who cannot play at least can root. Sports are healthful to both mind and body; through them muscles and traits of character grow strong at the same time. "A good sport" carries with it more than a merely technical application; it implies clean dealing and fairness in every game of life and typifies what we like to consider the 100 per cent. American.

Therefore the Red Cross has arranged for every variety of sport in which the convalescent men can participate and acts in co-operation with the Department of Physiotherapy in order that each man, according to his therapeutic needs, may be given the opportunity for the best physical training. For men not yet strong enough to indulge in any sport there are garden tools and seeds. Automobile rides are also provided. In hospitals where amputation cases are handled there are special games for one-armed or one-legged men, into which disabled athletes enter with all the zest of former days.

So it is that this organized recreational program does not allow a man to fall into any of the mental pitfalls which beset him after he has been drawn back out of the valley of the shadow. Often the tortures of the body have so drained the intellectual resources that a boy doubts whether the fight for life is worth the battle and if left to himself, he will let the quicksands of despondence engulf him.

Another type may make the still more pernicious mistake of thinking that because he has lost a leg or an arm or become otherwise crippled in the service of his country, that that country owes him a living, with no effort of his own. That country stands ready to give him every opportunity to take a new road in life; will stand back of him until he "makes good" and will continue his monetary compensation for life. But that country still demands and always will demand the spirit of "carry on" and the physical expression of it.

It is not easy to "carry on" when you have to do it in the dark and never again feel the glow that comes from viewing a gorgeous sunset, rolling green hills or any other of nature's beauties. With the first realization of a permanent physical handicap a mental depression is almost bound to seize the afflicted

one. But the spirit will conquer and environment is the most powerful stimulus to heroic will-power.

The organized recreational program which the Red Cross has put into effect in the military hospitals throughout the United States and has lately extended to the thirty-two hospitals operated by the United States Public Health Service at the request of Surgeon General Rupert Blue, creates healthful and stimulating environment. A man does not realize it, but he is something of a glorified kindergarten pupil. He is being given the chance to do those things he likes best in the way which will help him most in life.

Personal.

BRIG. GEN. GEORGE H. HARRIES, member, Illuminating Engineering Society, has recently had conferred upon him two new honors. One of these was the American Distinguished Service Cross conferred by General Pershing in recognition of his services at Brest in the early part of the war. The other was conferred by the French General Dupont, General Harries being made a commander of the Legion of Honor, also in recognition of his work at Brest.

PROF. A. E. KENNELLY, past president Illuminating Engineering Society and past president of Harvard University and the Massachusetts Institute of Technology, recently has been elected an Honorary Member of the Institution of Electrical Engineers in London.

COL. OSCAR H. FOGG, member Illuminating Engineering Society, has recently been appointed Secretary-Manager of the American Gas Association.

In September, 1917, Col. Fogg entered the military service as a Captain in the Ordnance Department, and was engaged in the design of plants and facilities for the repair and maintenance of ordnance material in France, and in the recruiting, organizing and training of enlisted and commissioned personnel for this purpose.

In France, he was first engaged with troops on the construction of ordnance base shops, and subsequently appointed Chief of Shop Organization and Maintenance Section and placed in charge of the organization, installation and operation of repair and maintenance establishments. Later, he was made Chief of the Construction and Maintenance Division of the Ordnance Department in France, the division which had supervision over all construction work and the operation of all repair and maintenance activities of the Ordnance Department in the American Expeditionary Forces, including the large base shops and the numerous smaller shops throughout France. Col. Fogg was honorably discharged from military service on March 31, 1919.

C. D. FAWCETT, formerly Assistant Secretary of the Society, who has been connected with the United States Shipping Board Emergency Fleet Corporation for one year, has recently been promoted to the position of Authorized Representative.

This office places Mr. Fawcett in charge of Emergency Fleet interest at the Ship Steel Fabricating Plants, Pottstown and Lettsdale, Pa. These two plants have combined capacity of 20,000 tons of fabricated ship steel per month, and turn out plates and steel shapes for use at Hog Island, Philadelphia.

Presentation of Popular Lectures.

The demand for the use of popular lectures is still great—at the High School at West Hartford, Conn., the lecture on "Home Lighting" was presented, which proved both interesting and educational, we are informed.

ILLUMINATION INDEX.

Prepared by the Committee on Progress.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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TRANSACTIONS

OF THE

Illuminating Engineering Society

PART I -- SOCIETY AFFAIRS

VOL. XIV JULY 21, 1919 No. 5

COUNCIL NOTES.

COUNCIL ITEMS OF INTEREST.

Report of Committee of Tellers.

NEW COUNCIL AND SECTION OFFICERS

Council accepted the report of the Committee of Tellers and confirmed the election of the Council and Section Officers for the fiscal year 1919-1920.

Following is a full list of Council and Section Officers who will act in their respective official offices for the year 1919-1920. (Those names in bold face type indicate newly elected officers.)

OFFICERS OF COUNCIL 1919-1920

President

S. E. Doane

Junior Past Presidents

George H. Stickney
George A. Hoadley

Vice-Presidents

Wm. J. Clark
Otis L. Johnson
H. K. Morrison
H. A. Hornor

General Secretary

Clarence L. Law

Treasurer

L. B. Marks

Directors

F. E. Cady
John C. D. Clark
E. C. Crittenden
Evan J. Edwards
R. B. Ely
Adolph Hertz
James J. Kirk
S. C. Rogers
P. S. Young

SECTION OFFICERS 1919-1920

New York Section

Chairman
F. M. Feiker

Secretary
R. E. Harrington

Managers
W. T. Blackwell
Wm. J. Clark
L. J. Lewinson
J. P. Radcliffe, Jr.
G. A. Sawin

New England Section

Chairman
H. F. Wallace

Secretary
Horace W. Jordan

Managers
G. N. Chamberlin
John C. D. Clark
J. W. Cowles
Raymond A. Fancy
F. A. Gallagher, Jr.

Philadelphia Section

Chairman

G. Bertram Regar

Secretary

H. B. Andersen

Managers

H. Calvert
C. E. Clewell
R. B. Duncan
Howard Lyon
W. L. Nodell

Chicago Section

Chairman

F. H. Bernhard

Secretary

E. D. Tillson

Managers

A. L. Arenberg
F. F. Fowle
E. H. Freeman
James J. Kirk
J. L. Stair

Annual Convention Details.

The annual convention of the Society will be held in Chicago, October 20 to 23 inclusive. The headquarters of the convention will be at the Hotel Sherman, where all meetings will take place.

The Convention Committee is as follows:

Homer E. Niesz, *Chairman*
Wm. A. Durgin, *Vice-Chairman*
Edwin D. Tillson, *Secretary*

F. H. Bernhard
S. E. Doane
Adolph Hertz
O. R. Hogue
H. A. Hornor
W. Greeley Hoyt
Otis L. Johnson
Clarence L. Law
L. B. Marks
H. K. Morrison
R. F. Schuchardt
L. C. Spake
George H. Stickney

George H. Stickney, Chairman Papers Committee

F. H. Bernhard, Chairman Sub-Committee on Local Arrangements

Adolph Hertz, Chairman Sub-Committee on Finance

R. F. Schuchardt, Chairman Sub-Committee on Entertainment

L. C. Spake, Chairman Sub-Committee on Publicity

Clarence L. Law, Chairman Sub-Committee on Transportation

Every effort is being made to have this coming convention the most successful in the history of the Society. The Electrical Show in Chicago will be running at the same time, which should be an added attraction for the visit of delegates to the convention.

An attractive and unusual papers program is being arranged by George H. Stickney, Chairman of the Papers Committee. Any suggestions for subjects that might be included in the papers program will be gladly received.

Report of Board of Examiners.

Upon the recommendation of the Board of Examiners the following were elected to membership in the Society:

Three Members.

Robert S. Hale
Supt. Special Research
Edison Elec. Illg. Co. of Boston,
39 Boylston St.,
Boston, Mass.

DR. A. J. LIEBMANN
General Manager,
Independent Lamp and Wire Co.,
1737 Broadway,
New York, N. Y.

E. W. LLOYD
Commonwealth Edison Co.,
72 W. Adams St.,
Chicago, Ill.

Two Transfers.

E. C. CRITTENDEN
Physicist,
Bureau of Standards,
Washington, D. C.

R. H. MAURER
Illuminating Engineer,
Consolidated Gas Co.,
130 E. 15th St.,
New York, N. Y.

Thirteen Associate Members.

R. J. BEAUMONT
General Manager,
Subsidiary Elec. Distribution Co.,
83 Craig St. West,
Montreal, Canada.

RICHARD HENRY BOWLES
Asst. Chief Electrical Engineer,
Sao Paulo Tramway, Light & Power Co.,
A Caixa Post,
Sao Paulo, Brazil.

JAMES KERR
Medical Research Officer,
London County Council,
2 Savoy Hill London, W. C. 2, England.

JAMES M. KETCH
Engineer,
National Lamp Works of G. E. Co.,
Nela Park,
Cleveland, Ohio.

ORMAN KOENES
Manager,
Wisconsin Gas & Electric Co.,
205 Main St.,
Watertown, Wis.

ERNESTO LIX-KLETT
Electrical Engineer and Managing Director,
E. Lix-Klett & Co.,
1099 Libertad,
Buenos Aires, Argentine Rep.

ELMER C. METZGER
Sales Manager,
M. F. M. Sales Co.,
703 Jefferson St.,
Buffalo, N. Y.

HERBERT PECHMAN
Electrical Engineering Department,
Polytechnic Institute of Brooklyn,
353 Rockaway Ave.,
Brooklyn, N. Y.

JAMES R. PEELE
Electrical Testing Lab.,
80th St. and East End Ave.,
New York, N. Y.

FREDERICK W. PRINCE
Illuminating Engineer,
Westinghouse Lamp Co.,
Bloomfield, N. J.

HOWARD A. SIMMONS
Industrial Illumination Rep.
Public Service Elec. Co.,
84 Sip Ave.,
Jersey City, N. J.

CLIFTON E. SMITH
Asst. Electrical Engineer
Lord Electric Co.,
105 W. 40th St.,
New York, N. Y.

EDGARD EGYDIO SOUZA
Electrical Engineer,
Sao Paulo Tramway, Light & Power Co.,
162 Caixa Postal,
Sao Paulo, Brazil.

SPECIAL ARTICLE.

President-elect Samuel Everett Doane 1919-1920.

Samuel Everett Doane was born at Swampscott, Mass., on February 28, 1870. He was graduated from the Swampscott High School in June, 1886, and was employed by the Thomson-Houston Co., at Lynn, Mass., from 1886 to 1892. He studied under tutors, and worked on the testing force or in the laboratory four nights each week for six years, and rose from office boy to acting engineer and assistant foreman of the incandescent lamp department. When the lamp department at Lynn was shut down in 1892 because of the panic, all of the employees were released with the exception of Mr. Doane, who was transferred to Harrison, N. J. He served the General Electric Co., from 1892 to 1897, as assistant engineer of the Harrison Lamp Works in 1892 and 1893, superintendent of the Harrison Lamp Works in 1893 and 1894, acting engineer of the foreign department at Schenectady later on, and from 1897 to 1900 was superintendent of the Bryan-Marsh Co., at Marlboro, Mass.

In 1900 Mr. Doane was made chief engineer of the National Electric Lamp Association and is now chief engineer of the National Lamp Works of the General Electric Co.

Mr. Doane is a fellow of the Institute of Electrical Engineers, a member of the Franklin Institute, the National Electric Light Association, Ohio Electric Light Association, the Rejuvenated Sons of Jove, the Electrical League of Cleveland, and is Honorary Vice-President and Honorary Life Member of the Colorado Railway, Light, Heat and Power Association.

COMMITTEE ACTIVITIES.

Final Meeting of the Committee on War Service.

This was a dinner-meeting held at the Engineers' Club, New York City, on the evening of June 11, 1919. The final report of the Committee as prepared for submission to the Council was presented. In winding up the affairs of the Committee the three following resolutions were adopted:

WHEREAS, the Committee on War Service, in closing its work, recognizes that its possibilities of service to the country during the war emergency were greatly enlarged through the kind offices of the National Committee on Gas and Electric Service, be it

Resolved, that the appreciation of this Committee is hereby tendered to the National Committee on Gas and Electric Service, both for the opportunities presented and for the privilege of co-operating with the National Committee on Gas and Electric Service in that Committee's loyal, disinterested service which was so ably rendered.

WHEREAS, it has been the privilege of the Illuminating Engineering Society, through its Committee on War Service, to render some assistance to the Government and to Government agencies during the war, and

WHEREAS, the service of this Committee has been rendered in part by members whose time and expenses have been contributed by corporations, be it

Resolved, that this Committee hereby expresses its appreciation of the support which it has received and extends to the corporations which thus broadmindedly have contributed to the success of its work during the stress of war its most earnest thanks.

Resolved, further that a copy of these resolutions together with a record of the Committee's work be sent to each of these corporations.

SAMUEL EVERETT DOANE

President-Elect of the Illuminating Engineering Society for the Fiscal Year 1919-1920.

Biography on page [illegible] of Part [illegible]

WHEREAS, the Committee on War Service of the Illuminating Engineering Society has been privileged to work in harmonious co-operation with the Divisional Lighting Committee of the Committee on Labor, Council of National Defense, the Chairman of which is numbered among the members of this Committee, and

WHEREAS, the Committee on War Service of the Illuminating Engineering Society recognizes the great value of the broadly constructive service which the Divisional Lighting Committee is rendering, be it

Resolved, that the Committee on War Service of the Illuminating Engineering Society at this, its final meeting, extend to the Divisional Lighting Committee its respectful compliments and its best wishes for further usefulness.

At the meeting of the Council on June 12, 1919, the Committee on War Service received a vote of thanks and was discharged.

NEWS ITEMS.

Honorary Membership—Edward L. Nichols.

At their meeting on June 12 the Council of the Society elected as honorary member of the Illuminating Engineering Society, Edward Leamington Nichols, Ph.D., Professor of Physics in Cornell University. This election was in recognition of the eminent contributions which Dr. Nichols has made to the science of illuminating engineering, and is in accordance with the conservative policy of the Society in thus honoring only those achievements contributary to the progress of illuminating engineering have been of a pre-eminent character. Prior to Dr. Nichols' election to honorary membership the only honorary member of the Society was Mr. Thomas A. Edison.

The Council commissioned Dr. C. H. Sharp to announce to Dr. Nichols his election as honorary member. This announcement was accordingly made at a dinner which was given in Dr. Nichols' honor at Cornell University, on the evening of June 19. This dinner, which was a mark of recognition of the services of Dr. Nichols to the University on the occasion of his retirement as head of the Department of Physics, was attended by about 250 people, including Dr. J. G. Schurman, President of the University, and many former members of the Department of Physics. The action of the Illuminating Engineering Society in electing Dr. Nichols an honorary member is a matter of great gratification to all of his many friends. Dr. Nichols signified his acceptance of the election and expressed the pleasure which this recognition of his work on the part of the Illuminating Engineering Society gave him.

In accordance with the Articles of Organization of the National Research Council, the Executive Committee of the Engineering Division has drawn lots to ascertain the period of service of each member of the Division. The term of service as determined in this manner for our representative, Dr. Edward P. Hyde, is two years.

A course of ten lectures on Safety Fundamentals was given in New

York under the auspices of the Safety Institute of America. The eighth lecture on Illumination was given on May 10, by Mr. R. E. Simpson, member, I. E. S. associated with The Travelers' Insurance Co. The purpose of the course of lectures was to portray to factory inspectors the basic principles of accident prevention. Following this line the lecture on Illumination described the general principles of good lighting, and showed how violation of these principles impair vision, and thus become a contributary cause of accidents.

Dr. Loyd A. Jones, who was associated with Lt. Van Buskirk and Lt. Warner on Marine Camouflage, during the period of the war, contributed at the May meeting of the New York Section, an abstract of a paper entitled "The Low Visibility Phase of Marine Camouflage." It has been found impracticable to print Dr. Jones' admirable treatise on the subject, owing to its exhaustive character and consequent great length. It is to be hoped that members of the Society, and others, interested in the subject, will have the opportunity of reading Dr. Jones' article in full, in some other publication.

Presentation of Popular Lecture.

Prof. A. H. Ford, Physics Department at the State University of Iowa presented before a student audience the popular lecture on the Lighting of the Home, on June 25.

A doctor of medicine, Paul K. Sellew, at Los Angeles, Cal., has become interested in the lecture on the Lighting of the Home, to the extent of presenting it before a special audience.

Requests were received from various sources for the loan of these lectures. An association known as the National Automotive Sprinklers' Association, formed to conserve life and property from fire, has also become interested in the popular lectures.

Personals.

GEORGE ELLERY HALE.

George Ellery Hale, Director of the Mount Wilson Observatory and Foreign Secretary of the National Academy of Sciences, who has been for the last ten years a correspondent of the *Academie des Sciences,* Institut de France, has received the unusual honor of election as Associe Etranger, taking the place of Adolph von Baeyer, declared vacant by the Academy.

The Foreign Associates are limited to twelve, and the high distinction has been held by only two Americans—Simon Newcomb and Alexander Agassiz.

The National Research Council upon the presentation and acceptance of Dr. Hale's resignation as its Chairman and the election of James R. Angell as his successor, created and bestowed in perpetuity upon Dr. Hale the title of Honorary Chairman, in recognition of his services to the National Research Council and to Science and Research by indefatigable efforts that have contributed so largely to the organization of science for the assistance of the Government during the war, and the augmentation of the resources of the United States through the newly intensive cultivation of research in the reconstruction and peace periods that follow.

S. E. DOANE.

Information has just been received from the General Office that President-elect Doane was recently appointed Honorary Vice-President of the Illuminating Engineering Society of London.

GENERAL OFFICE.

The reports of the various committees of the Society should be prepared and forwarded to the General Secretary as soon as convenient. The General Secretary's report for the year is based on material which is taken from these reports and in order that the report may be finished in time for presentation to the Council at its last meeting of the season, material should be in the General Office by August 15.

OBITUARY.

Word has just reached the General Office, that C. J. R. Humphreys, who resided at Lawrence, Mass., died on June 30, 1919.

BOOK REVIEW.

The Blind—Their Condition and the Work Being Done for Them in the United States—Harry Best, Ph. D. Published by the Macmillan Co., New York; 763 pages with index and many tables and references; price $4.00.

An exhaustive study of blindness from the standpoint of the individual, covering the social, economic, legal, educational and organized-welfare status of blind people in this country. A section of particular interest to illuminating engineers discusses the causes of blindness and its prevention, both by general procedure and by organized movements. Other sections of the book are devoted to provision for the education of blind children, intellectual provision for the adult blind; economic welfare of blind people in general; and organizations interested in the blind.

The author recognizes the work of the Illuminating Engineering Society by a number of references in the section devoted to the cause and prevention of blindness. These will be found on pages 123, 209 and 212.

ILLUMINATION INDEX.

Prepared by the Committee on Progress.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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The Searchlight Projector as Used in the Mercantile Marine—	R. C. Harris	April 11	444
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Illumination and Some of Its Fundamental Considerations. (Abs. from Tran. South African Instn. Elec. Engrs., Vol. 9, part II, Dec. 1918, pp. 192-198)—	H. A. Tinson	May	20a
Gas Age			
A 4-500 B. t. u. Gas for Great Britain—		June 2	569
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Some Notes on Railway Lighting and its Maintenance—	A. Cunnington	Mar.	57
The Group and Duct System of High Pressure Gas Lighting—	News Item	April	108
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TRANSACTIONS

OF THE

Illuminating Engineering Society

PART I -- SOCIETY AFFAIRS

VOL. XIV AUGUST 30, 1919 No 6

COUNCIL NOTES.

ITEMS OF INTEREST.

On July 9th, Council Executive Committee met at which time the Board of Examiners recommended to election of membership the following:

Five Associate Members.

DR. ING N. A. HALBERTSMA,
Consulting Illuminating Engineer,
3 Emmalaan,
Utrecht Netherlands.

FRANK SHAW,
Publicity Manager,
British Thomson-Houston Co., Ltd.,
77 Upper Thames St.,
London, E. C. 4, England.

W. J. MCCALLION,
Electrical Engineer,
Department of Public Works,
Sydney, N. S. W., Australia.

B. DAWSON STARR,
Industrial Lighting Salesman,
Commonwealth Edison Co.,
72 West Adams St.,
Chicago, Ill.

MASAKI TSUKASAKI,
Electrical Engineer,
Tokyo Electric Co.,
Kawasaki-Machi near Tokyo,
Japan.

SECTION ACTIVITIES.

Resumption of Section Activities.

With the closing of the Summer Season and the renewing of activities that usually follows in its wake, thought, time, and energy are bent again toward attaining record-breaking Section Activities.

It is customary that during this month the outgoing and incoming Section Boards meet to discuss ways and means for continuing Section affairs.

Upon Section officers depend a good deal the quality of membership and papers presented and in general the channels through which the Society disseminates the knowledge of the art and science of illuminating engineering.

While the war was being fought, our Section officers, like most everybody else, were called upon to assist in doing their "bit" in one way or another. Notwithstanding the added burdens that they were called upon to shoulder, the Sections of the Society suffered little, if any at all, from too little thought of Section officers, to the great work of the Illuminating Engineering Society.

And now particularly with the ceasing of hostilities all eyes are again directed toward Section officers who we trust will help make 1919-1920 a year illuminated with their efforts to maintain the traditions and ideals of the Illuminating Engineering Society.

CONVENTION.

All indications point to a most successful convention which will be held on October 20th to 23rd inclusive, at the Hotel Sherman, Chicago, Ill.

The membership has already been advised by the President of the date and place of the Convention and through supplementary data will be issued further details regarding the programme of papers, entertainment and exhibition.

Members desiring to contribute papers for the Convention are urged to forward their manuscripts for visé to Mr. G. H. Stickney, Chairman, Committee on Papers, Fifth & Sussex Streets, Harrison, N. J., to reach him not later than September 5, 1919.

NEWS ITEMS.

Lectures on "The Conservation of Eyesight of School Children" are being delivered before a class on School Hygiene at the Cleveland Normal School, by Mr. M. Luckiesh, Physicist, Nela Research Laboratory, Nela Park, Cleveland, Ohio. On July 8th, 9th and 10th Mr. Luckiesh presented a series of lectures on Light, Color and Vision at the University of West Virginia. Mr. Luckiesh has devoted a great deal of time and thought to the study of the conservation of vision from all angles, and has contributed to the illuminating engineering world a vast number of books dealing specifically with light, color and vision.

From the office of Arthur Woods, Assistant to the Secretary of War, a request has been received to circulate information pertaining to the citations awarded to employers who have re-employed those who formerly worked with them, and left to serve in the Army or Navy during the great war.

The citation carries with it permission for the holder to display on the firm's service flag the shield of the United States as a symbol that it will fulfil its obligations to the men who went to the defense of the country at the time of its peril. The document is signed by the Secretary of War, the Secretary of the Navy, and the Assistant to the Secretary of War. It is handsomely engraved and engrossed with the name of the recipient.

To secure the citation nothing is necessary for an employer except to write to Arthur Woods, Assistant to the Secretary of War, Washington, D. C., of his intentions to employ everybody who formerly worked with him, and left to serve in the Army or Navy during the great war.

The Department of Electrical Engineering in co-operation with the Illumination Committee of the Ohio Electric Light Association have started a campaign for improved industrial illumination.

Below are quoted excerpts from the prospectus issued by The Ohio State University outlining the correspondence course on Industrial Lighting.

"Industrial lighting has undergone a complete revolution within the past five years. It is a fact, not generally appreciated, that the man who is familiar with the principles of modern and efficient illumination has the power to increase the output of most factories from 8 to 27 per cent., or even more.

"These principles form the subject matter of a correspondence or extension course now being published by the De-

partment of Electrical Engineering of the Ohio State University. This is a series of twelve technical letters in which the facts most essential to the successful designing of factory lighting systems are explained in a simple and practical manner.

"Such subjects as the following are dealt with,—factory lighting requirements, electric lamp and reflector characteristics, lighting installation design, wiring methods, costs, maintenance.

"Much value is added to the course by frequent reference to a selected list of technical trade literature, which through the courtesy of the manufacturers, will be supplied with the letters to all who ask for it. Subscribers will please indicate in their orders whether they care to receive this material.

"This work has been undertaken because improvement in industrial lighting will work to the advantage of all concerned; the price charged, two dollars, is barely sufficient to cover the cost of printing. The present edition is a small one so that early ordering is suggested.

"A set of practical problems accompanies each "technical letter" and the answers follow in the next letter. For those who care for supervision in the working of these problems, arrangements for assistance can be made at a slight additional charge. A certificate will be awarded to all who complete the course under this arrangement.

"Address Department of Electrical Engineering, Ohio State University, Columbus, Ohio."

Personal.

Lieut. Samuel G. Hibben, formerly of Pittsburgh, dropped in at the General Office a few days ago. In his modest way he told us of his work over there; first with the famous "Searchlight Division" and finally with the American Peace Commission. He was prevailed upon to jot down his thoughts in connection with the Illuminating Engineering Society and its work, and this is what he handed us:

"Upon my return to the States I am quite naturally in a mood to be pleased with a large number of things, but especially am I glad to see that the Society is 'carrying on' so well. Overseas we were frequently and forcibly reminded of the need of better illumination, and after a six months' residence in Paris, I have no doubts whatever of the useful work that this kind of an organization can yet accomplish, both here and abroad.

"Hence my pleasure to be able to find the Society surviving the war. I hope soon to be able to join in with the good work, and greet all the good friends and members."

GENERAL OFFICE.

The General Secretary's Report is under compilation and its completeness depends upon the Chairman of Committees and Section Secretaries who have already been requested to forward their reports for the year 1918-1919 to Mr. Clarence L. Law, General Secretary, Irving Place and 15th Street, New York, N. Y.

The report of the General Secretary is a feature of the Convention and those Chairman and Section Secretaries who have not rallied to the first call of the General Secretary are hereby requested to submit their reports at the earliest possible date.

In this issue will be found the Membership List of the Illuminating Engi-

neering Society. At the General Office all efforts have been directed to keep pace with the hundreds of changes of positions and addresses, particularly of those men who have returned from war service.

The General Office would appreciate hearing from members whose addresses do not appear correctly in the new membership list.

Section Secretaries are requested to turn in at the General Office their section card file of the membership.

Work on correcting these files commences during the early part of September and Section Secretaries who have not already forwarded their files to the General Office are requested to do so immediately.

The addresses of the following war service members are desired at the General Office:

Guy S. Brandreth,
Paul C. Egan,
Alfred W. Heitman,
Maurice Holland,
Eugene Peterson.

Communications relating to the whereabouts of the aforementioned members should be addressed to the General Office of the Society.

An organization meeting was held at Association Island, Henderson Harbor, N. Y., by the President-elect, S. E. Doane, and several prominent members of the Society, who discussed plans for the coming administration.

ILLUMINATION INDEX.

Prepared by the Committee on Progress.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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Improved Methods of Shop Lighting. (From *Power Plant Engr.*, Vol. 23, No. 10, May 15, 1919, pp. 457-459)—		July 4	18a
Gas Journal			
Use of Wood for Lighting Gas in Germany—	News Item	May 20	427
Upright and Inverted Incandescent Gas Burner Tests—	News Item	June 3	565-609
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Gas Equipment in Relation to Housing Schemes—Lighting—	H. Masterton	June 10	749
General Electric Review			
Mazda Lamps for Motion Picture Projection—	L. C. Porter	July	556
Industrial Management			
Illumination and the Safety Problem. (Abstract from *Coal Indus.*, April 1919, pp. 153-156)—		July	86
Journal of Electricity			
Electrical Features of Portland's Victory Rose Carnival—	F. D. Weber	July 15	60
Journal of Franklin Institute			
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Note on the Distribution of Energy in the Visible Spectrum of a Cylindrical Acetylene Flame—	Edw. P. Hyde, W. E. Forsythe, F. E. Cady	July	129
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A Demonstration of the Uses of Invisible Light in Warfare—	R. W. Wood	June 15	232
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Some Orienting Effects of Monochromatic Lights of Equal Intensities on Fucus Spores and Rhizoids—	Annie May Hurd	June	201
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Determination des flux lumineux directs. (Abstract)—	R. Dispenza	May 17	153D
Sphere pour la determination des angles solides it des flux lumineux. (Abstract)—		May 17	154D
Amelioration des installations d'eclairage du Canal Kaiser-Wilhelm. (From *Elek. Tech. Zeit.*, Jan. 2, 1919, p. 8)—		June 14	189D
L'eclairage produit par les projecteurs a miroir parabolique et la tolerance admissible dans la distance focale du miroir. (From *Elettrotecnica*, Jan. 25, 1919, p. 42)—		June 14	189D
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Daylight Saving Should Continue—	Editorial	July	210

Report of Committee on Electric Headlights, A. R. E. E.—	News Item	July	211
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A Better Searchlight Unit—	Albert A. Pashby	June 21	657
Scientific American Supplement			
Recent Developments in Marine Lighting. II—		June 21	388
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ILLUMINATING ENGINEERING SOCIETY MEMBERSHIP LIST.

1—Sustaining Members.

2—Honorary Members, Members and Associate Members.

The member's full name, business title and address is given. The grade of membership is indicated by (H) for Honorary Member, (M) for Member, and (A) for Associate Member. A star, *, precedes the name of all charter members. Members who have served the Society as officers of the Council have the official position and duration of office indicated in italics.

SUSTAINING MEMBERS.

The official representative of each company is given.

ALEXALITE COMPANY,
432 E. 23rd St., New York, N. Y.
Official representative:
Plant, Herman

AMERICAN GAS & ELECTRIC CO.
30 Church St., New York, N. Y.
Official representative:
Tidd, Geo. N.

AMERICAN OPTICAL CO.
Southbridge, Mass.
Official representative:
Tillyer, E. D.

BENJAMIN ELECTRIC MFG. CO.
120 S. Sangamon St., Chicago, Ill.
Official representative:
Johnson, Otis L.

BOSTON CONSOLIDATED GAS CO.
24 West St., Boston, Mass.
Official representative:
Wrightington, E. N.

BROOKLYN EDISON CO., INC.
360 Pearl St., Brooklyn, N. Y.
Official representative:
Wells, W. F.

BROOKLYN UNION GAS CO.
176 Remsen St., Brooklyn, N. Y.
Official representative:
Staniford, Arthur F.

CENTRAL HUDSON GAS & ELECTRIC CO.
129 Broadway, Newburgh, N. Y.
Official representative:
Beal, A. R.

COMMONWEALTH EDISON CO.
28 N. Market St., Chicago, Ill.
Official representative:
Hogue, Oliver R.

CONSOLIDATED GAS, ELECTRIC LIGHT & POWER CO. OF BOSTON
100 W. Lexington St., Baltimore, Md.
Official representative:
Schmidt, William, Jr.

CONSOLIDATED GAS CO. OF NEW YORK
130 E. 15th St., New York, N. Y.
Official representative:
Addicks, W. R.

COOPER HEWITT ELECTRIC CO.
8th & Grand Sts., Hoboken, N. J.
Official representative:
Evans, W. A. D.

CUTLER-HAMMER MFG. CO.
37 So. 12th St., Milwaukee, Wis.
Official representative:
Fleet, A. H.

DAWES BROTHERS
1615 Harris Trust Bldg., 111 W. Monroe St., Chicago, Ill.
Official representative:
Dawes, Rufus C.

DUQUESNE LIGHT CO.
435 Sixth Ave., Pittsburgh, Pa.
Official representative:
Harris, Henry

EDISON ELECTRIC ILLUMINATING CO., OF BOSTON
30 Boylston St., Boston, Mass.
Official representative:
Edgar, C. L.

EDISON ILLUMINATING CO. OF DETROIT
Detroit, Mich.

EDISON LAMP WORKS OF GENERAL ELECTRIC CO.
Harrison, N. J.
Official representative:
Page, A. D.

ELECTRICAL TESTING LABORATORIES
80th St., & East End Ave., New York, N. Y.
Official representative:
Millar, Preston S.

GILL GLASS CO., INC.
Amber & Venango Sts., Philadelphia, Pa.
Official representative:
Gill, Chas. H.

GILLINDER & SONS, INC.
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*WILLIAMS, ARTHUR (M)
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Director, 1911-13.
General Commercial Manager, New York Edison Co., Irving Place and 15th St., New York, N. Y.

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WRAY, EDWARD (A)
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WRIGHTINGTON, EDGAR N. (M)
Director, 1909-11.
Vice-President, 1912.
Second Vice-President, Boston Consolidated Gas Co., 24 West St., Boston, Mass.

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WYLIE, ARTHUR G. (A)
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Assistant Secretary, The New York Mutual Gas Light Co., 142 E. 15th St., New York, N. Y.

YOUNG, J. W. (M)
c/o Oakland Motor Car Co., Pontiac, Mich.

YOUNG, P. S. (M)
Director, 1917-20.
Treasurer, Public Service Corporation of New Jersey, 80 Park Place, Newark, N. J.

YOUNG, R. R. (A)
New Business Agent, Public Service Electric Co., 80 Park Place, Newark, N. J.

YOUNG, WM. ALBRECHT (M)
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TRANSACTIONS
OF THE
Illuminating Engineering Society
PART I -- SOCIETY AFFAIRS

VOL. XIV — OCTOBER 10, 1919 — NO. 7

COUNCIL NOTES.

ITEMS OF INTEREST FROM THE COUNCIL EXECUTIVE COMMITTEE MEETING HELD ON SEPT. 11, 1919.

At the last meeting of the 1918-1919 Council Executive Committee the following were elected to membership:

One Sustaining Member.

B. C. COBB
President, Consumers Power Co.,
14 Wall St.,
New York, N. Y.

Two Members.

H. H. BARROWS
Manager,
Oakland Mazda Lamp Division of G. E. Co.,
1648 16th St.,
Oakland, Cal.

A. G. WORTHING
Physicist,
Nela Research Laboratory,
Nela Park,
Cleveland, Ohio.

Four Associate Members.

G. F. EVANS
Sales Engineer,
National X-Ray Reflector Co.,
429 Columbus Savings & Trust Bldg.,
Columbus, Ohio

R. N. FALGE
Illuminating Engineer,
Goodyear Tire & Rubber Co.,
East Market St.,
Akron, Ohio.

ARTHUR MILLER
Salesman,
Ivanhoe Regent Works of G. E. Co.,
105 West 40th St.,
New York City.

HOMER E. NIESZ
Assistant to Vice-President,
Commonwealth Edison Co.,
72 West Adams St.,
Chicago, Ill.

CONVENTION NOTES.

No greater tribute can be paid to the members of the Convention Committee, who planned the Thirteenth Annual Convention of the Society at Chicago, Ill., on October 20th to 23rd,—than that it was a huge success. All who were there will agree that everything was done to make the convention an interesting and successful one,—and interesting and successful it was.

From the moment that the convention was formally opened, every moment was consumed in a most pleasant manner. From the papers program listed on the following page, it can be easily recognized that the wide range of subjects invited at all sessions a host of members and guests. To those who planned the entertainment all credit is due for the enlivened and amusing hours spent.

A volume of space could be devoted to describing at length the features of the program. Briefly, however, this is what occurred:

MONDAY, OCTOBER 20

Registration—9.30 A. M to 12.30 P. M.
Opening Session—2.00 P. M. to 5.00 P. M.

Subject	Author
Address of Welcome	Louis A. Ferguson, Vice-President, Commonwealth Edison Co., Chicago, Ill.
Response	L. B. Marks, Consulting Engineer, New York City.
President's Address	Dr. George A. Hoadley, Swarthmore, Pa.
General Secretary's Report for Council	Clarence L. Law, New York Edison Company, New York City.
Committee on Progress	F. E. Cady, Chairman, National Lamp Works, Cleveland, Ohio.
Committee on Automobile Headlighting Specifications	Dr. Clayton H. Sharp, Chairman, Electrical Testing Laboratories, New York City.
President's Reception	Evening.

TUESDAY, OCTOBER 21

Outdoor Lighting and Photometry—9.30 A. M. to 12.30 P. M.

Subject	Author
Street Lighting with Low Mounted Units, Kensico Dam Drive	C. A. B. Halvorson, Engineer, General Electric Company, West Lynn, Mass. A. B. Oday, Illuminating Engineering, Edison Lamp Works, Harrison, N. J.
Developments in Street Lighting Units (Electric)	A. D. Cameron, Schenectady, N. Y. C. A. B. Halvorson, Engineer, General Electric Company, West Lynn, Mass.
Recent Development in Gas Street Lighting	F. V. Westermaier, Engineer, Welsbach Street Lighting Company, Philadelphia, Pa.
Military Searchlights	Captain Chester Lichtenberg, Office of the Chief of Engineers, War Department, Washington, D. C.
A Universal Photometric Integrator	F. A. Benford, Illuminating Engineering Laboratory, General Electric Company, Schenectady, N. Y.
A Photoelectric Photometry	Dr. A. H. Compton, Westinghouse Company.

Visit to Electrical Show at the Coliseum—2.00 to 5.00 P. M.

Theatre Party	Evening.

WEDNESDAY, OCTOBER 22

Industrial Lighting Codes—9.30 A. M. to 12.30 P. M.

Subject	Author
Glare Measurements	Ward Harrison, Illuminating Engineer, National Lamp Works, Cleveland, Ohio.

Symposium—Application of Industrial Lighting Codes:

Conducted by	L. B. Marks, Consulting Engineer, New York City.

(a) Code in Wisconsin ....J. A. Hoeveler, Electrical Engineer, Wisconsin Industrial Commission, Madison, Wis.

(b) Code in New York ....J. H. Vogt, Director of Industrial Hygiene, State Industrial Commission, New York City.

(c) Code in New Jersey ......R. H. Leveridge, Chief of the Bureau of Electrical and Mechanical Equipment, Department of Labor, Trenton, N. J.

(d) Code in Pennsylvania ....J. S. Spicer, Division of Hygiene and Engineering, Department of Labor and Industry, Harrisburg, Pa.

(e) Federal Code ....Dr. M. G. Lloyd, Bureau of Standards, Washington, D. C.

(f) Insurance Inspectors and the Code ....R. E. Simpson, Engineer, Travelers Insurance Indemnity Company, Hartford, Conn.

Commercial Aspects—2.00 P. M. to 5.00 P. M.

Opportunities for Extending Lighting Through New Applications ....R. M. Searle, Vice-President, Rochester Railway & Light Co., Rochester, N. Y.

Lighting in England ....F. W. Willcox, British-Thomson-Houston Co., London, England.

A Survey of Industrial Lighting in Fifteen States ....R. O. Eastman, Fuller & Smith, Cleveland, Ohio.

Automobile Trip for the Ladies—2.00 to 5.00 P. M.

Subscription Banquet ....Evening

THURSDAY, OCTOBER 23

General Practise—9.00 A. M. to 12.30 P. M.

SUBJECT — AUTHOR

Factory Lighting, A Central Station Problem ....O. R. Hogue, Head Lighting Agent, James J. Kirk, Illuminating Engineer Commonwealth Edison Co., Chicago, Ill.

Illumination of Artistic Interiors Without Use of Pendant Ceiling Fixtures ....Augustus D. Curtis, President
J. L. Stair, Chief Engineer, National X-Ray Reflector Co., Chicago, Ill.

Coefficients of Light Utilization ....Ward Harrison and E. A. Anderson, Illuminating Engineers, National Lamp Works, Cleveland, Ohio.

Walls and Floors—Their Effects on Lighting ....Van Rensselaer Lansingh, Engineer, Cincinnati, Ohio

Inspection Trip—2.00 to 5.00 P. M.

Inspection of Illumination of Chicago Telephone Building, and Commonwealth Edison Buildings.

To the New York Section was awarded the historic gavel, for having present at the convention the largest number of members travelling the greatest distance.

NEWS ITEM.

From Japan came the following letter of acceptance of honorary membership in the Illuminating Engineering Society, recently conferred upon Dr. Edward L. Nichols:

Nikko, Japan,
September 1, 1919.

Dr. C. H. Sharp,
Electrical Testing Laboratories, N. Y.

Dear Dr. Sharp:

My election to honorary membership in the Illuminating Engineering Society, announcement of which you made in such felicitous words at the Physics dinner, just before my departure from Ithaca was unexpected, undeserved, I know, but most highly appreciated.

Kindly convey to the Society my heartfelt appreciation and glad acceptance.

It has been a source of regret that the diversion of my work into other channels has prevented me from contributing more to the activities of the Society but my interest in its growth has been intense from the beginning.

I desire to take this opportunity to congratulate you and others of the little group of pioneers in the development of this new branch of applied science upon the success of your efforts. The Illuminating Engineering Society of to-day is a fitting and splendid symbol of what you have accomplished.

With best regards and with greetings across the sea, I remain

Yours very truly,
(Signed) Edw. L. Nichols.

Motor Transport Training Schools of the Army.

The United States Army is definitely launched in the field of vocational training for the motor transport corps. It has no option in the matter, for men skilled in automotive vehicle operation and repair do not exist in anything like adequate numbers for the requirements even of civil life; and the war with Germany has demonstrated that no matter how good our Army may be in other respects, its efficiency will be conditioned by that of the motor transport branch.

Therefore, the Army is organizing schools to train men in the various branches of automobile repair, construction, and operation. They are real schools under trained teachers where the time of the pupil is wholly devoted to receiving instruction.

Apart from the military necessity, the automotive industries will benefit by the establishment of this training system.

The United States Civil Service Commission is receiving applications to fill 150 positions of assistant instructor in motor transport training schools. The entrance salaries range from $1,800 to $2,400 a year. Detailed information may be obtained from the U. S. Civil Service Commission, Washington, D. C., or from the secretary of the U. S. Civil Service Board at the post office or customhouse in any city.

ILLUMINATION INDEX.

Prepared by the Committee on Progress.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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TRANSACTIONS

OF THE

Illuminating Engineering Society

PART I -- SOCIETY AFFAIRS

VOL. XIV | NOVEMBER 20, 1919 | NO. 8

COUNCIL NOTES.

ITEMS OF INTEREST FROM THE COUNCIL MEETING.

At the meeting of the Council held on November 20, 1919 the following were elected to membership.

Three Members.

FRED T. BENSON,
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Chicago, Ill.

F. A. KARTAK,
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School of Engineering of Milwaukee,
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Milwaukee, Wis.

ROSS BOOK MATEER,
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1000 Chestnut St.,
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Thirty Associate Members.

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Chicago, Ill.

D. AXMAN,
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Edison Lamp Works,
922 Monadnock Bldg.,
Chicago, Ill.

F. W. BURKHOF,
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Louisville, Ky.

PAUL C. BURRELL,
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Herman Andrae Elec. Co.,
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Milwaukee, Wis.

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J. W. FOSTER,
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Duplex Lighting Works,
6 W. 48th Street,
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E. G. B. FOX,
Commercial Engineer,
General Electric Co.,
Harrison, N. J.

ALFRED R. HOLDEN,
Dept. of Design,
The B. F. Goodrich Co.,
S. Main St.,
Akron, Ohio

CHARLES HOWARD,
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Commonwealth Edison Co.,
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M. C. HUSE,
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DAVID A. JONES, JR.,
Designing Elec. Engineer,
Semet Solvay Co.
Syracuse, N. Y.

L. C. KENT,
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S. C. LYONS,
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J. W. MACKIE,
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188 Ellison St.,
Paterson, N. J.

J. F. MAYO,
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Consumers Power Co.,
Jackson, Michigan.

E. F. NEWKIRK,
Display Advertising,
Edison Lamp Works,
Harrison, N. J.

R. D. OBERMEYER,
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National Lamp Works,
Nela Park,
Cleveland, Ohio.

WM. M. ROSBOROUGH,
Illuminating Engineer,
National Lamp Works,
Nela Park,
Cleveland, Ohio.

GEO. K. SEVERN,
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Commonwealth Edison Co.,
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ED. L. SCHOLL,
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WALTER STURROCK,
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National Lamp Works,
Nela Park,
Cleveland, Ohio.

S. W. THOMPSON,
Sales Engineer,
Commonwealth Edison Co.,
72 W. Adams St.,
Chicago, Ill.

Reinstatement.

F. G. STROUD,
Public Works Dept.,
Parliament Bldg.,
Toronto, Ont., Canada.

SECTION ACTIVITIES.

New York.

Meeting—Octob 1919.

The first meeting of the New York Section of the Illuminating Engineering Society, was held on the evening of October 2nd at which time a paper on "Home Lighting—How to Make It Comfortable and Effective" was presented by Messrs. Powell and Harrington. Approximately one hundred and fifty mem-

bers and guests were in attendance at this meeting and it was noted that among this number were many from the electrical contracting field. Considerably valuable discussion was received from this meeting.

Meeting—November 13, 1919.

Application of Industrial Codes was the subject discussed at this meeting. To this meeting were invited electrical contractors, dealers and representatives from organizations in the manufacturing garment trade.

Constructive and interesting discussion followed the presentation of the paper. The paper and discussions presented at the convention and subsequently at this meeting of the New York Section, appear in Part II of this issue.

Philadelphia.

Meeting—October 17, 1919.

The first meeting of the year was held in the auditorium of the Engineers' Club, 1317 Spruce Street, on October 17, 1919, at 8:00 p. m., with Mr. G. Bertram Regar, Chairman, presiding. The meeting was especially favored in having as speakers, Past President Dr. George A. Hoadley, and President S. E. Doane, who addressed those present on the subject of what the Illuminating Engineering Society has accomplished, and what it is believed that its scope will be during the coming year. Both addresses were most interesting and instructive. The following persons participated in the discussion:

> Messrs. W. J. Serrill, C. E. Ferree, George S. Crampton, J. D. Israel, Clayton W. Pike, C. E. Clewell and Merritt C. Huse.

The meeting was preceded by a dinner at the Arcadia Cafe at which twenty-eight members and guests were present. The good spirit both at the meeting and at the dinner encouraged the Philadelphia Section to feel sure that the coming year is to be a very successful one.

Meeting—November 21, 1919.

The monthly meeting of the Philadelphia Section was held in the Hotel Emerson, Baltimore, Md., on November 21st, 1919 at 8:00 p. m., under the auspices of, and jointly with, the Electric Technical Group of the Baltimore Consolidated Gas, Electric Light and Power Company's Section of the National Electric Light Association.

Mr. H. C. Louis, Chairman of that Group, called the meeting to order, and presented Mr. W. T. Bradley, Chairman of the Consolidated Company's Section, N. E. L. A., who welcomed the Philadelphia delegation. Mr. G. Bertram Regar, Chairman of the Philadelphia Section, I. E. S. responded and took the chair.

The first paper of the evening was by Mr. George H. Stickney, on "Industrial Lighting". The second paper was by Mr. M. Luckiesh, on "Lighting and the Householder". Then Professor Gataro Yamakawa, President of the Illuminating Engineering Society of Japan, addressed the meeting and was followed by Mr. Herbert A. Wagner, President of the Consolidated Company of Baltimore, who spoke on the importance of illumination, and advocated the co-operation of the electrical contractors, fixture manufacturers, architects, and all other persons who were directly or indirectly interested in the subject.

A dinner preceded the meeting at which forty-nine were present. The attendance at the meeting was one hundred and eighty.

CONVENTION NOTES.

From countries and states bordering on both sides of the Atlantic and Pacific Oceans, delegates came to the recent convention of the Society held in Chicago, Illinois. From the Far East came Professor Yamakawa, Past President of the Illuminating Engineering Society of Japan; from England, Francis W. Willcox; from Los Angeles, Cal. and Portland, Oregon, came C. M. Masson and F. H. Murphy, Local Representative. Quoted below is Professor Yamakawa's speech:

> "MR. PRESIDENT AND GENTLEMEN: It is a great pleasure for me to be here at the thirteenth annual convention of your Society, and I thank you most heartily for the invitation you have so kindly extended to me.

I was in this country in 1896 and in 1898. So this is my third visit in America. Since I reached San Francisco in July I have traveled through many states and have noticed the remarkable advance America has made in sciences and industries during the past two decades. I was struck especially by the marvelous development of illuminating engineering, and this development, I feel sure, is greatly due to the contribution made by the members of your society to the various branches of both science and industry throughout these many years. In Japan our illuminating engineering society was organized three years ago. We have at present something like 750 members. The Society has its own journal, which is issued four times a year. It is needless to say that Japan is far behind the time in the science of illumination and we Japanese are striving hard in order to catch up.

"For whatever progress we have achieved so far in sciences and industries we are very much indebted to America. We know it, and are grateful. In this particular field of illuminating engineering we have a great deal to learn from your country. Our Society looks up to your Society for guidance which will be given, I trust, as willingly and as generously as heretofore.

"I thank you all once more for the privilege of attending this convention and desire to express my sincere wish for the prosperity of this Society for many years to come."

RESOLUTIONS ON PRESIDENT HOADLEY'S ADDRESS.

The preceding issue of the TRANSACTIONS contained the address of President Geo. A. Hoadley—which adddress he presented at the annual convention recently held in Chicago. A committee of three, namely, D. McFarlan Moore, Chairman; C. M. Masson and Norman Macbeth, framed the following resolutions, which are worthy of mention and place in the TRANSACTIONS.

"The Committee on the President's address reports as follows: The responsibility for the guidance of our Society largely rests upon its President, and at the close of each administration it behooves its membership to listen most attentively to the wisdom expressed by its retiring leader. Your Committee finds the address of our worthy President George A. Hoadley to fully maintain the very high standard established by his predecessors.

"He has admonished this Society to put forth special efforts during these days of Reconstruction following the Great World War, to bend its greatest efforts towards aiding in increasing production of all kinds by the proper utilization of light and he has encouraged the idea of reciprocal relations with other organizations together with a hearty endorsement of the extension of research work to corporations and manufacturers.

"Whereas, President Hoadley's administration was begun under wartime conditions and therefore frought with unusual difficulties and,

"Whereas, at its close it is apparent that the Society has experienced a year filled with opportunities, that have been grasped, to serve our Country and Humanity.

"Therefore, be it resolved,

"That the President's address be received most graciously, and that the thanks of this Society be extended to President Hoadley for his splendid address and for his arduous labors in behalf of our organization during the past year, and,

"Be it further resolved, that a copy of these resolutions be sent to President Hoadley and that they be spread upon the minutes of the Society and printed in its TRANSACTIONS.

"Signed by the following committee:

CHAS. M. MASSON,
NORMAN MACBETH,
D. MCFARLAND MOORE, *Chairman*."

NEWS ITEMS.

Divisional Lighting Committee of the Committee on Labor, Council of National Defense.

The Divisional Lighting Committee of the Committee on Labor of the Council of National Defense was disbanded on Dec. 1, 1919. A report on the plan and scope of the work of this Committee and its activities during the war emergency was presented at the 12th Annual Convention of the Illuminating Engineering Society, New York, October 10, 1918, and published in Volume XIII of the TRANSACTIONS, pages 528 and 529.

The state representatives of this committee whose names were designated by the Illuminating Engineering Society, have been invited to serve as Advisory Members of the Committee on Lighting Legislation.

A letter recently written by Leon Gaster, Honorable Secretary of the Illuminating Engineering Society of London, contains the following paragraph. We have not asked Mr. Gaster's permission to reprint this paragraph, and yet we feel certain that he would not deny us the pleasure to take this opportunity and means of informing the membership what our sister society in London thinks of the work of the American Illuminating Engineering Society.

"I should like to say that the maintenance of the good work of the Illuminating Engineering Society in the United States, at a time when the war had greatly checked the dissemination of information on illumination in Europe, was extremely gratifying to us. Let us hope that with the resumption of more normal conditions more rapid progress will now be made in all parts of the world."

In the issues of the *Saturday Evening Post,* dated November 15 and December 6, 1919, Floyd Parsons, in his article entitled "Everybody's Business," has written some very interesting paragraphs on Street Lighting, Factory Lighting and its Relation to Accident Hazards, the Foot-Candle Meter, Floodlighting and Searchlighting.

OBITUARY.

Three deaths were reported.

FRANK L. MASON,
Columbia University,
New York, N. Y.

ALBERT MYER,
Albert Lea, Minn.

W. D. WEAVER,
Charlottesville, Va.

I. E. S. Council Resolutions on Death of William Dixon Weaver.

A committee appointed by Council, and consisting of A. S. McAllister, Chairman; C. O. Bond and L. B. Marks, submitted the following resolutions on the death of William Dixon Weaver, which Council accepted by a rising vote. The resolutions are as follows:

Whereas, The Council of the Illuminating Engineering Society has learned with sorrow of the sudden peaceful passing away in sleep during the night

of November 1, 1919, of our charter member William Dixon Weaver, whose active interest in our Society was maintained without interruption from the date of its foundation to the time of his death; and

Whereas, he served the Society with distinguished loyalty and success as Chairman of the Committee which drafted the initial Constitution and By-Laws, in 1905; as one of the first Directors elected in 1906; as Chairman of the first Committee on Editing and Publication; as Chairman of the first Committee on Finance; as Chairman of the Committee on Securing New Members in 1907; as Chairman of the Committee on Papers in 1908; as a member of the Committee on the I. E. S. Lecture Courses at Johns Hopkins University in 1910, and also at the University of Pennsylvania in 1916; as Chairman of the Committee on Revision of the Constitution in 1915, and as a member of the Committee on Revision of the Constitution and By-Laws when death overtook him; and

Whereas, all members of the Illuminating Engineering Society, and especially the members of the Council, with a full appreciation of the invaluable aid rendered to the Society by Mr. Weaver, desire these facts to be placed on record; therefore be it

RESOLVED: That in the death of Mr. Weaver we have lost a true friend whose untiring interest in the Illuminating Engineering Society, complete sympathy with its objects, and labors in its service were ever directed towards the promotion of its welfare and the realization of its highest ideals; and be it further

RESOLVED: That these resolutions be spread upon the minutes of the Council, and printed in the TRANSACTIONS of the Society, and that a copy be sent to Mrs. Weaver.

ILLUMINATION INDEX.

Prepared by the Committee on Progress.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

American Gas Engineering Journal			
Device Invented for Reducing Heating Power of Natural Gas to 600 B. t. u.—	News Item	Sept. 13	226
Central Station			
Studies in Economics of Lighting—	E. Leavenworth Elliott	Sept.	65
Industrial Lighting. III—	Harrison and Magdsick	Sept.	74
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A Few Examples of Weave Room Illumination in Textile Mills—	Kenneth A. McIntyre	Oct. 1	43
Lighting Efficiency Foremost in Design of New Plant at Montreal—		Oct. 1	51
Illumination of a New School at Lennoxville, Que.—		Oct. 1	52
Approximate Intensities of Illumination Demanded by the Different Classes of Industry—		Oct. 1	54
Electrical Review (London)			
Electrified Seed—	News Item	Aug. 15	210
An Aeroplane Factory Lighting—		Aug. 29	207
Scientific and Industrial Research—		Sept. 5	[illegible]
Electrical Review (U. S.)			
What Better Industrial Lighting Can Do to Stimulate Production—	F. H. Bernhard	Sept. 6	381
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Development of the Chicago Street-Lighting System—	William G. Keith	Oct. 4	559
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Better Lighting of Highways—	Editorial	Oct. 18	657
Store and Industrial Lighting Campaigns Successful—	News Item	Oct. 18	666
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Subway Lighting for New Cleveland Bridge—	Ward Harrison and Earl A. Anderson	Sept. 6	513
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Lighting for Production in Fine Weaving Plant—	E. Du B. Stryker	Sept. 20	641
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Industrial Lighting—	Editorial	Sept. 5	239
The Lighting of an Aeroplane Factory—	News Item	Sept. 5	258
The Effect of Electric Light on the Eye—	Herr Reichenbach	Sept. 12	272
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Lampes a incandescence dans l'azote, a bas voltage—		July 31	44
Engineering Index			
Journal Soc. Chem. Indus. (Vol. 38, No. 12, June 30, 1919, pp. 168T-171T). The Regenerative Effect as Influencing Lighting Efficiency of the Inverted Incandescence Burner—	J. S. G. Thomas	Sept.	30a
Rivista Marittima, (Vol. 52, No. 5, May 1919, pp. 195-208). Luminous Power of Lighthouse Lenses—	A. Coacci		

Gas Journal (Vol. 147, No. 2920, July 1, 1919, pp. 29-30). Street-Lighting Reconstruction Problems—	L. Gaster			
Prof. Memoirs, Corps Engrs. U. S. Army & Engr. Dep. (Vol. 11, No. 56, Mar.-Apr. 1919, pp. 139-149). The Developments of Anti-Aircraft Searchlights—	Jas. B. Cross			
Industrial Management				
Improved Methods of Shop Lighting—		Sept.		
Power Plant Eng. (Vol. 23, No. 10; May 15, 1919; pp. 457-459)—				
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Uniform Street Lighting Procedure in London—	News Item	Aug.	19	399
Scientific and Industrial Research Report—		Sept.	2	502
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Phot. Korr., 1918, p. 379—				
The Gray Wedge Photometer as Applied to Botanical Problems—	W. Kecht	Sept.		
The Position of the Lamps in Enlarging Apparatus for Diffused Light (from Phot. Rund, 1917, p. 211)—	P. Thieme	Sept.		311
Light Filters for Cutting Out Ultra-Violet Radiation—	P. R. Kogel	Sept.		35
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Condition of Research in the United States—	A. M. Greene, Jr.	Sept.		587
Industrial Research Laboratory Organization—	C. E. K. Mees	Sept.		667

The Organization of an Industrial Laboratory (1918)—	A. D. Little and H. E .Howe	Sept.	663
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Report on the Applicability of Ultra-Violet Rays to Signaling—	Irwin G. Priest and K. S. Gibson	Aug.	188
A New Formula for the Spectral Distribution of Energy from a Complete Radiator. II, Concerning the Value of the Constant D_2—	Irwin G. Priest	Aug.	191
The Spectral Transmission of Filters Used to Detect Camouflage or Improve Visibility—	K. S. Gibson, E. P. T. Tyndall and H. J. McNicholas	Sept.	260
A Method for the Color Grading of Red Flares—	Irwin G. Priest	Sept.	264
Comments on Spectral Radiation Formulae—	W. W. Coblentz	Sept.	267
The Reflective Power of Metals and Dielectrics in the Ultra-Violet—	E. P. Lewis and A. C. Hardy	Sept.	272
Philosophical Magazine			
A Syntonic Hypothesis of Color Vision with Mechanical Ilustrations—	E. M. Barton and H. M. Browning	Sept.	338
A Theory of Color Vision—	R. A. Houston	Sept.	402

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On the Transmission of Speech by Light—	A. O. Rankine	Aug. 15	242
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Visibility of Bright Lines—	Louis Bell	Oct. 3	331
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High-Lights of Air-Travel—	M. Luckiesh	Sept. 20	280
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TRANSACTIONS
OF THE
Illuminating Engineering Society
PART I -- SOCIETY AFFAIRS

VOL. XIV DECEMBER 30, 1919 No. 9

COUNCIL NOTES.

ITEMS OF INTEREST.

Upon the recommendation of the Board of Examiners, the following were elected to membership in the Society:

One Member.

WM. EDWARD BUSH,
Illuminating Engineer,
The British Thomson Houston Co.,
77 Upper Thames St.,
London, England.

Seven Associate Members.

C. M. FARMER,
Power Engineer
New Bedford Gas and Edison Lt. Co.,
693 Purchase St.,
New Bedford, Mass.

L. G. HINWOOD,
Manager, Supply Dept.,
Australian Gen. Elec. Co.,
Cor. Queens & Little Collins Sts.
Melbourne, Australia.

J. K. JOHNSTON,
General Manager,
Bryan Marsh Division G. E. Co.,
33 Union Square,
New York, N. Y.

LOUIS MACKOSEB,
Illuminating Engineer,
Westinghouse Lamp Co.,
Bloomfield, N. J.

P. C. NEALE,
Engineering Department,
Nela Park,
Cleveland, Ohio.

J. W. NORDGREN,
Sales Engineer,
National X-Ray Reflector Co.,
235 W. Jackson Blvd.,
Chicago, Ill.

J. B. SEAMAN,
Engineer of Installations Division,
Philadelphia Elec. Co.,
226 S. 11th St.,
Chicago, Ill.

One Reinstatement.

ALLEN M. PERRY (Associate)
Engineering Editor,
Electrical World,
36th St. and Tenth Ave.,
New York, N. Y.

At the last meeting of the Council, the President suggested the idea that members present questions for research work which the Society could undertake to consider. It was thought that questions such as glare, relation of proper lighting to working conditions and such like could be submitted to colleges and universities to form a thesis of this work. Members who have any suggestions which might be considered in this direction are asked to forward them to the General Secretary.

SECTION ACTIVITIES

CHICAGO.

January 9th—"Electrical Distributions for Street Lighting".—This was an afternoon and evening session under the auspices of the American Institute of Electrical Engineers to which the Chicago Section of the I. E. S. was invited to join.

Three papers were presented:

"Series System of Distribution" by W. P. Hurley.

"Multiple Systems of Distribution" by Ward Harrison.

"Constant Potential Series Distribution" by Dr. C. P. Steinmetz.

The proposed meetings of the Chicago Section for the remainder of the fiscal year are printed below:

February 19th—"Essentials of Fixture Design for Type C Lamps".—An illustrated paper by Ward Harrison, Illuminating Engineer of the National Lamp Works of the General Electric Co. A special effort is to be made for a full attendance from fixture manufacturers, jobbers and dealers, of which there are quite a large number in Chicago.

March 18th—"How Artificial Light is Used by the Householder", by W. A. Durgin, Lighting Assistant to the Vice-President, Commonwealth Edison Co. The above title has not been furnished by Mr. Durgin, but it is understood that such a title indicates roughly the tenor of his paper, which is based on an extensive survey being conducted by the Commonwealth Edison Company at this time.

April 15th—"New Aspects of Residence Lighting".—An illustrated lecture by M. Luckiesh, Physicist, Nela Research Laboratory. Original ideas will be presented putting residence lighting on a new plane.

May 13th—"School Lighting".—It is hoped that it will be possible to have Professor F. C. Caldwell of the Ohio State University present a paper on this subject, dealing particularly with childrens' eyesight, raising the utilization of investment in school buildings by the general use of school rooms in the evenings. It is hoped to call attention to the requirements of good school lighting, common faults, remedies, and the value of good example and precedence on the minds of children at a receptive age largely through actual school lighting installations of a high order.

NEW YORK.

Meeting—January 8, 1920.

A very successful joint meeting of the New York Section of the Illuminating Engineering Society and the New York Division of National Council Fixture Manufacturers attended by over 300 was held on January 8, 1920. Approximately 70 members attended the usual informal a la carte dinner before the meeting.

Two papers were presented, one entitled, "What the Illuminating Engineer can do for the Fixture Manufacturer," by W. R. McCoy of the National Council Fixture Manufacturers, the other, "Brightness: the Fundamental in Illuminating Engineering" by Bassett Jones of the Illuminating Engineering Society.

Considerable discussion followed the reading of these papers.

The aim of the meeting was to form a basis for the getting together of these two societies with the hope of a mutual exchange of ideas.

PHILADELPHIA.

Meeting—December 8, 1919.

The monthly meeting of the Section was held in joint session with the Philadelphia Section, American Institute of Electrical Engineers, on December 8, 1919, 8:00 P. M., at the Engineers' Club of Philadelphia, 1317 Spruce Street. The meeting was opened by Professor C. E. Clewell, Section Chairman, American Institute of Electrical Engineers, who resigned the chair in favor of G. Bertram Regar, Section Chairman, Illuminating Engineering Society. Mr. Regar introduced Dr. C. H. Sharp, of the Electrical Testing Laboratories, New York, who presented a paper on "The Regulation of Automobile Headlighting", prepared by himself and Mr. W. F. Little. Dr. Sharp's lecture included an interesting history of this legislation, an account of the appointment by the Illuminating Engineering Society of a committee to investigate this subject, and a description of the tests made and the resultant conclusions. Mr. Little exhibited slides showing the effects of light, correctly and incorrectly directed from the headlights of an approaching automobile. The most interesting discussion which followed the presentation of this paper was opened by Mr. Benjamin C. Eynon, Registrar of Motor Vehicles of the State of Pennsylvania, and was participated in by a large number of gentlemen.

The dinner preceding the meeting was held at the Arcadia Cafe, at 6:30 P. M.

Program for the balance of the current year is printed below:

January 16, 1920.

"School Lighting"—(Illustrated with Lantern Slides.) By M. Luckiesh, Physicist, Nela Research Laboratories, Cleveland, Ohio.

February 20, 1920.

"Artificial Daylighting Equipment"—(Illustrated by Practical Demonstrations.) By Norman Macbeth, Illuminating Engineer, Artificial Daylighting Company, New York.

Cosmos Club, Washington, D. C.

March 19, 1920.

"Development of the R. L. M. Standards for Industrial Lighting"—(Illustrated with Lantern Slides.) By Ward Harrison, Illuminating Engineer, National Lamp Works, Cleveland, Ohio.

'Residence Lighting"—(Illustrated with Lantern Slides.) By M. Luckiesh, Physicist, Nela Research Laboratories, Cleveland, Ohio.

(This meeting will be under the auspices of the Washington Section A. I. E. E.)

April 16, 1920.

"Daylight Saving"—(Illustrated with Lantern Slides.) By Preston S. Millar, General Manager, Electrical Testing Laboratories, New York.

May 21, 1920.

"Color Photography"—(Illustrated with Motion Pictures.) By Henry Hess, Hess-Ives Corporation, Philadelphia, Pa.

Highland Park, Pa.

June 14, 1920.

Joint Outing with the Philadelphia Section, American Institute of Electrical Engineers at the Howard McCall Field.

NEW ENGLAND.

Meeting—December 12, 1919.

The New England Section held its first meeting of the season on December 12, in Boston when Mr. Luckiesh ad-

dressed the Section on "Analysis of Residence Lighting". Mr. Luckiesh has devoted considerable time and study to this phase of illumination and his talk before the New England Section was received with as much enthusiasm as were his talks on the same subject delivered before the other Sections of the Society.

The next meeting of the Section will be held sometime in February.

COMMITTEE ACTIVITIES.

Advisory Members of Committee on Lighting Legislation;

The following state representatives of the Divisional Lighting Committee, which was disbanded December 1, 1919 as noted in the November issue of the TRANSACTIONS, have accepted the invitation of the Chairman of the Committee on Lighting Legislation to serve as Advisory Members of that Committee for the year 1920:

Alabama

HOWARD M. GASSMAN,
Consulting Engineer,
Birmingham.

Arkansas

PROFESSOR WM. GLADSON,
University of Arkansas,
Fayetteville.

California

ROMAINE W. MYERS,
Oakland.

Delaware

WM. A. DANNENHAUER,
Wilmington.

Georgia

RAWSON COLLIER,
Georgia Railway & Power Co.,
Atlanta.

Idaho

WM. H. P. HILL,
Boise Commercial Club,
Boise.

Iowa

PROF. L. B. SPINNEY,
Department of Physics,
Iowa State College,
Ames.

Kansas

PROF. GEO. C. SHAAD,
University of Kansas,
Lawrence.

Louisiana

PROF. DOUGLAS ANDERSON,
Dept. of Electrical Engineering,
Tulane University of Louisiana,
New Orleans.

Maine

PROF. W. E. BARROWS,
Dept. of Electrical Engineering,
University of Minnesota,
Minneapolis.

Montana

J. F. ROCHE,
Montana Power Company,
Butte.

Michigan

PROF. JOHN C. PARKER,
University of Michigan,
Ann Arbor.

Minnesota

PROF. GEO. D. SHEPARDSON,
Dept. of Electrical Engineering,
University of Minnesota,
Minneapolis.

Missouri

PROF. H. G. HAKE,
Dept. of Electrical Engineering,
Washington University,
St. Louis.

Nebraska

D. E. Byerley,
Lincoln Gas & Electric Light Co.,
Lincoln.

New Hampshire

W. G. Africa,
Peoples Gas Light Company,
Manchester.

New Jersey

Lewis T. Bryant,
Commissioner of Labor,
Trenton.

New York

John H. Vogt,
Division of Industrial Hygiene,
New York State Industrial Commission,
New York.

North Carolina

Prof. Wm. Hand Browne, Jr.,
Dept. of Electrical Engineering,
N. Carolina State College,
West Raleigh.

North Dakota

Prof. D. R. Jenkins,
Dept. of Electrical Engineering,
University of North Dakota,
Grand Forks.

Pennsylvania

Prof. C. E. Kinsloe,
Dept. of Electrical Engineering,
Pennsylvania State College,
State College.

Rhode Island

Prof. Arthur E. Watson,
Brown University,
Providence.

South Carolina

John C. Felton,
Charleston Consolidated Railway & Lighting Co.,
Charleston.

South Dakota

Prof. L. E. Akeley,
University of South Dakota,
Vermillion.

Virginia

Prof. Walter S. Rodman,
Dept. of Electrical Engineering,
University of Virginia,
Charlottesville.

Washington

Prof. Fred. A. Osborn,
University of Washington,
Seattle.

West Virginia

Prof. C. W. Waggoner,
Dept. of Physics,
University of W. Virginia,
Morgantown.

Lighting Legislation Committee Bulletin;

(a) *California Industrial Lighting Code:*

The General Lighting Safety Orders issued by the Industrial Accident Commission of the State of California became effective in that State on December 1, 1919. These Orders, together with an appendix of general information and suggestions relating thereto, are issued in printed form in a pamphlet containing 63 pages.

There are nine Orders covering Lighting, Artificial Light, Measurements, Shading of Lamps for Overhead Lighting, Shading of Lamps for Local Lighting, Distribution of Light on the Work, Emergency Lighting, Switching and Control Apparatus.

The Orders are based upon the general requirements in the I. E. S. code and follow rather closely the Orders of the Wisconsin code, though there are

some departures from the latter and from other State codes now in force as follows:

Artificial Light: Under the heading "Foot-candles at the Work", it is stipulated that no illumination is required in "Processes otherwise safeguarded in which light is detrimental".

Distribution of Light on the Work: It is stipulated that where overhead lighting is required to supplement "local lighting" the overhead lighting shall have "a minimum (intensity) of not less than one-fourth (¼) foot-candle".

Emergency Lighting: It is stipulated that "Emergency illumination shall not exceed fifty (50) per cent. of the distributed illumination" and that "Emergency lighting systems shall be supplied from a source independent of the regular lighting system in theatres, public meeting halls, moving picture exhibition places, hospitals, schools, and any other place where the nature of the hazard is such as to require it, except where an exemption is granted by the Industrial Accident Commission".

In the Appendix is given a table of desirable illumination for general classes of work and a table of recommended intensities (expressed in foot-candles) for detailed operations and processes. These tables follow the lines laid down in the New York State Code, except that in the New York Code the table of intensities for detailed operations and processes relates to minimum intensities only.

The General Orders are mandatory requirements. The stipulations in the Appendix are not mandatory .

(*b*) *Oregon Industrial Lighting Code:*

Pursuant to the provisions of Chapter 181, Section 8 of the General Laws of Oregon for 1919 (effective May 29, 1919), the Commissioner of Labor appointed a Lighting Commission, of which Mr. F. H. Murphy, Portland, is Secretary. This Commission has submitted its report in the form of a lighting bulletin embracing the legislative act, together with the lighting rules determined by the Commission, and explanatory notes forming an appendix to these rules. The bulletin follows the general lines laid down in other State codes; the rules are compiled from those in codes now in force, some being taken from one code, some from another. A departure is made in the rule relating to distribution of light on the work, as follows:

Distribution of Light on the Work: It is stipulated that where overhead lighting is required to supplement "local lighting" the overhead lighting shall have "a minimum (intensity) of not less than one-half (½) foot-candle".

In the Appendix, the definition of terms, the detailed explanation of the rules and their application, are treated at great length. For instance under the heading "glare", four kinds of glare (high intensity, contrast, veiling, shifting) are described and remedies are suggested for preventing or minimizing glare.

The Appendix contains a long table of "preferable" foot-candle intensities for detailed operations and processes.

(*c*) *School Lighting Code, New York State:*

The Illuminating Engineering Society Code of Lighting School Buildings has been officially recognized by the New

York State Department of Education, as a guide for the artificial lighting of school buildings. The new edition of the school building regulations of this State, will contain the following reference note:

> "In passing upon the artificial lighting of school buildings, we shall be guided by the Code of Lighting of the Illuminating Engineering Society, a copy of which may be secured by addressing the Illuminating Engineering Society, 29 West 39th Street, New York, N. Y.

Nomination of Officers for Coming Year.

The nomination of officers for the coming year is now under consideration by the Committee on Nomination of which Mr. George H. Stickney, Junior Past President is Chairman. The officers to be elected are: a President, three (3) Vice-Presidents and three (3) Directors, General Secretary and Treasurer. The ticket prepared by the Committee shall be printed and forwarded to members of the Society not later than May 5th for voting.

Under the Constitution, a member of the Society may vote an official ticket or may substitute a written ballot, containing names of his own selection.

NEWS ITEMS.

The National Committee for the Prevention of Blindness, Incorporated, has recently issued a "Manual for Conservation of Vision Classes" which is devoted to procedure in saving the sight of school children having defective vision. Very properly this contains a chapter on lighting, both natural and artificial. In accordance with the established policy of the Committee this chapter is based largely upon the literature of the Illuminating Engineering Society, especially in this case the Code of Lighting School Buildings to which reference is made. Copies of the Manual may be obtained from the National Committee for the Prevention of Blindness, Incorporated, 130 East 22nd Street, New York, N. Y.

"The Society has received a copy of the Report of the President of the United States National Committee of the International Commission on Illumination for the year 1918-1919. The principal feature of the Report consists of a statement and discussion of the recommendation from the President of the International Commission and the Honorary Secretary that the Commission should be reorganized, and, that the reorganization should be centered around the Allied countries with the probability of participation by those neutral nations which have especial interest in its proceedings.

"Sometime ago the United States Committee outlined certain activities as suitable for presentation to the Commission and the present report reviews the status of these activities with the hope that a comprehensive statement with recommendations may be available at the first technical session of the reorganized Commission."

Interesting to note is the article printed below which is reprinted here from *The New York Times* dated December 23, 1919.

We learn that a new artificial light said to effect the closest approach to daylight, is on exhibition at the Ameri-

can Chamber of Commerce in London. With due credit to *The New York Times,* we reprint the paragraphs dealing with the new light:

"The apparatus consists of a high-power electric light bulb, fitted with a cup-shaped opaque reflector, the silvered inner side of which reflects the light against a parasol-shaped screen placed above the light. The screen is lined with small patches of different colors, arranged according to a formula worked out empirically by Mr. Sheringham, the inventor, and carefully tested and perfected in the Imperial College of Science and Technology.

"The light thrown down from the screen is said to show colors almost as well as in full daylight. Under the new light delicate yellows were quite distinct, indigo blues were blue, cobalts had their full value, and violets lost the reddish shade, which they display in electric light.

"The American Chamber says a great future is expected for this invention in such uses as the lighting of show windows and art galleries, studio work of all kinds, dyeworks, tea and tobacco blending, and many other industries. Color photography will also probably benefit from it."

On December 24, the following day, there appeared on the editorial sheet of *The New York Times* the following paragraphs:

"An artificial light in which all colors would have their true value—the value, that is, which they have in sunlight—has long been sought, but hitherto has not been found, though several of the illuminants already in use come not far from being what is wanted. Now, according to a London dispatch, there is on exhibition in the American Chamber of Commerce a light that is better than any other except daylight and reveals all colors as what they are to a degree never before attained.

"But the explanation of the new device is puzzling, for, as described, it consists essentially of an electric bulb whence light rays pass to a screen bearing various colors and thence are reflected. The implication of this is, or seems to be, that a colored screen can give to light falling on it the colors it bears. Of course it could do no such thing in the sense of adding to light a color it did not already possess. The glass of a red lantern does not make red light; it merely absorbs the rays of other colors and lets only the red ones pass through. The service of the variegated screen must be the subtraction of undesired rays; it cannot add the desired ones."

The coming meeting of the Lighting Fixture Manufacturers of New York to be held in Detroit—Hotel Statler during the week of February 8th should be of considerable interest to all members. This branch of the industry playing a very important part in lighting matters should have the attention of those affiliated with lighting. For this reason it is urged that all those who can find it convenient to attend one or more sessions of this meeting should do so, as it would pay. An exhibition of fixtures is being made at this time. Further information can be given by the Secretary, Mr. J. L. Wolf in Detroit.

It has come to the attention of the General Secretary that there is a demand for the services of illuminating engineers or those who have had some experience in the lighting industry. Any

members wishing to make new affiliations will be given further information by communicating with the General Secretary.

Speeding Up the Chickens with Mazda Lamps.*

Increased production is the order of the day. In the industrial work the plant with the best lighting system has the best production record, other things being equal.

But lighting for increased production profits is not limited to industrial plants.

The farmer, and more particularly the poultry raiser, can use light to his great advantage. But farmers and poultry raisers as a whole do not realize this and it's going to be immensely to the advantage of dealers in farm lighting plants and Mazda lamps who acquaint them with the facts.

Poultry raisers, State Agricultural Experiment Stations, and schools have investigated the relation of lighting to poultry raising and egg production and by extensive experiments have proved the reliability of reports that more eggs will be produced, especially during the short days of the winter months, if hen houses are lighted and hens given additional feed and kept awake longer than the natural day. These results are obtained without detrimental effect on the hens or effecting their laying records for the summer months.

* Reprinted from the Stimulator of the National Lamp Works.

ILLUMINATION INDEX.

Prepared by the Committee on Progress.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

Proceedings American Institute of Electrical Engineers			
The Searchlight in the U. S. Navy—	Ralph Kelly	Dec.	1369
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Modification of Planck's Radiation Formula—(From Deutsch, Phys. Gesell., Verh. 21, p. 294, 1919)—	W. Nernst and T. Wulf	Nov. 29	522
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Lighthouses for Airmen—	News Item	Dec. 13	586
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TRANSACTIONS
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PART II -- PAPERS

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LIGHT AS AN AID TO THE TRANSPORTATION OF MATERIAL.*

A. L. POWELL AND R. E. HARRINGTON.

The war has placed exacting demands on industry and the reconstruction period will require great quantities of manufactured products. How can industry proceed if, with the plants producing huge outputs, the products cannot be moved to the places where required? The factor of transportation is of parallel importance to output.

It can easily be shown and has been demonstrated, to our sorrow, that a weakening of this important link in our system seriously impairs the entire industrial organization. If for one reason or another a terminal becomes congested, this is reflected along the whole line back to the producer. Embargoes are put on and the manufacturers are forced to let up on their output. Each plant depends on others for parts and raw materials. It is, therefore, evident that anything which will help our transportation problem is a factor in our industrial program.

The authors believe, and trust that they can prove to you, that proper and adequate lighting does facilitate the movement of material. Modern methods of illuminating warehouses, express and freight stations and piers thus indirectly increase and expedite production.

Speeding of shipment by good lighting is increased through the following direct causes:

(*a*) greater actual speed of trucking, etc.
(*b*) markings more easily read

The indirect effects are

(*c*) less mis-sent shipments
(*d*) reduction of spoilage and thefts
(*e*) improved relations with the public

* Paper prepared for presentation before the New York Section of the Illuminating Engineering Society, New York, N. Y., December 12, 1918.

These are not theoretical statements, but are borne out in practice.

(A) If a pier or freight station is dimly lighted, many portions in deep shadow, truckers must proceed cautiously, watching out for objects lying about on the floor, for they lack the confidence which comes with clear vision. Accident reports reveal that one of the most common causes is stumbling or falling. With poor lighting this hazard is increased. Not only does an accident affect the injured worker, but it has a demoralizing effect on the entire force. Each workman becomes over-cautious and slows down his movements. Proper light, therefore, increases the speed of freight handling.

(B) In sorting freight or express packages or stowing them aboard ship, it is of course necessary to read and check the labels or markings. It is self-evident that with plenty of light less time will be spent on this step of the handling. In many stations there are only a few spots where there is enough illumination to read labels, and material actually has to be moved there to be sorted. Certainly this extra handling is not efficient.

(C) Conversation with express officials indicates that one of their serious troubles is mis-sent shipments. Inadequate illumination is an important contributing cause. The reading matter on waybills is often faint or blurred and many packages are badly addressed. The chances for error under poor light are great. Packages sent to the wrong place sometimes never return. Perishable freight is often entirely lost if mis-sent. Occasionally an entire factory is held up awaiting the arrival of goods, the delay in transportation being due to a mis-sent shipment. Beyond the delay and cost of locating mis-sent material, there follows a further load on the transportation system of sending to proper destination.

(D) Spoilage of goods is reduced if there are no dark corners in which packages of perishable material become hidden. Again, boxes that have been broken in shipment are readily caught and taken care of before a greater loss is sustained. Breakage is bound to be reduced, for employees will not throw articles about promiscuously if the place is well enough lighted so that they are likely to be seen. Theft is greatly reduced, as the sneak thief

would not dare to pry open a bundle and remove part of the goods if the chances of detection were high.

(E) Modern business methods have made it important to please the public. Common carriers desire to have the most cordial relation with shippers. If consignments are delivered promptly in undamaged condition, if the mis-sent shipments are eliminated, then the transportation agents should have the good will of the people.

In spite of all these actual advantages of proper lighting, the subject apparently in many instances has not been given the attention it deserves. It is the purpose of this paper to point out methods through which the desirable results can be attained with minimum expense. It is also hoped that this brief presentation may call the matter forcibly to the attention of some of the officials in charge, that they may see the importance of the subject and give it the attention and study which it deserves.

Investigation has been made of a considerable number of buildings of the class under consideration and this reveals that in general the standards of illumination are far too low for the most economic operation. Not only is insufficient light furnished, but in a great majority of cases antiquated equipment is employed. Obsolete types of incandescent lamps, inefficient carbon arc lamps and open flame gas burners are more prevalent than in almost any other field the authors have investigated. Even where efficient lamps are employed, frequently light is wasted through the absence of proper reflectors. In many cases where reflectors are installed, they have not been well maintained, becoming very dirty, rusted and in some cases actually falling apart. Incandescent lamps are allowed to burn after becoming badly blackened and gas mantles which have half broken off are still in service.

It is apparent that the effect of light colored surroundings in increasing the illumination is not fully realized. Ceilings and walls have been allowed to become almost black, reflecting practically no light. A little white paint will save a great deal on the lighting bill and allow increased utilization of daylight.

In an investigation of 58 large steamship piers in New York City, as regards the artificial lighting, data was obtained on the size of the pier, number and size of lighting units, spacing and

height of lamps, height of ceiling, color of walls and ceilings, class of traffic, watts per square foot and general artificial lighting conditions.

The investigators were experienced illuminating engineers, competent to evaluate the resultant illumination. An analysis of the results showed that 6.2 per cent. had good illumination, 51.2 per cent. fair illumination and 42.6 per cent. illumination which was entirely inadequate and generally poor. The average watts per square foot of those piers electrically lighted was 0.16, with a maximum of 0.34 and a minimum of 0.05. Very much better illumination results would have been obtained in practically all the cases if the equipment had been well maintained and surroundings given an occasional coat of whitewash or other light paint. Three and six-tenths per cent. of the piers had white walls and ceilings, 9.1 per cent. light colored, 20 per cent. medium colored, 52.8 per cent. dark and 14.5 per cent. very dark (almost black) surroundings.

The above data justifies the foregoing criticisms. Such conditions would not be tolerated for the handling of materials in ordinary manufacturing plants, and the surprising feature is that it has been possible to get along at all with such poor light.

A few representative installations of tungsten filament lamps are presented in Table A. The figures given above, of course, include many other installations.

A similar investigation of some of the larger railway freight stations in the metropolitan district disclosed conditions as outlined in Table B.

GENERAL REQUIREMENTS OF LIGHTING.

Enough light must be provided to read markings, labels and waybills without eyestrain, and to see one's way about the entire area.

If the first requirement is provided for, the safety element would naturally be taken care of. The Illuminating Engineering Society's Code of Lighting for Factories, Mills and Other Work Places, which has been adopted as mandatory in a number of States, provides a minimum intensity of ¼ foot-candle for pas-

TABLE A.—DATA ON TYPICAL PIERS.—METROPOLITAN DISTRICT.

	Size lamps	Hanging Height	Spacing	Watts per sq. ft.	Color Ceiling	Color Walls	Reflector	Remarks
Case A	100 watt 4 light clusters	15 ft.	40x50	0.20	dark	dark	dome	Spacing too wide for hanging height. Inefficient lighting units. Illumination results fair.
Case B	250 watt	18 ft.	50x50	0.10	light	dark	dome	Spacing too wide for hanging height. Results generally poor
Case C	250 watt	15 ft.	30x40	0.20	dark	dark	Radial Wave	Lighting results good.
Case D	400 watt	14 ft.	50x100	0.08	dark	dark	dome	Spacing too wide for hanging height Wattage too loo. Results poor.
Case E	100 and 150 watt	15 ft.	30x30	0.16	dark	dark	dome	Conditions generally fair.
Case F	250 watt	20 ft.	irregular	0.07	light	light	dome	Spacing too wide for hanging height. Wattage too low. Results poor.
Case G	100 and 200 watt	18 ft.	various	0.09	dark	dark	dome	Results poor.
Case H	100 and 200 watt	20 ft.	20x35	0.18	light	light	dome	Illumination generally satisfactory
Case I	400 watt	25 ft.	80	0.06	white	dark	dome	Spacing too wide for hanging height Wattage too low. Results poor.
Case J	400 watt	15 ft.	50	0.16	white	dark	dome	Spacing too wide for hanging height Wattage fair. Results fair.
Case K	100 watt	15 ft.	various	0.04	dark	dark	dome	Entire system poor
Case L	100 watt 4 light clusters	15 ft.	30x60	0.22	dark	dark	dome	Results fair, but spacing too wide
Case M	150 watt	18 ft.	30x60	0.08	light	dark	dome	Spacing too wide for hanging height Wattage too low. Results poor.
Case N	100 watt 4 light clusters	25 ft.	40x78	0.13	light	light	dome	Inefficient lighting unit. Spacing satisfactory Lighting results fair
Case O	250 watt	20 ft.	70x50	0.07	dark	dark	none	Conditions very bad

TABLE B.—DATA ON TYPICAL FREIGHT STATION—METROPOLITAN DISTRICT.

	Size lamps	Hanging height, feet	Spacing	Watts per sq. ft.	Color		Re-flector	Condi-tion	Remarks
					Ceiling	Walls			
Case A	25 and 40 watt	12	12 x 17	0.15 ave.	dark	dark	flat	very dirty	Arrangement good. Intensity too low. Poorly maintained, reflector inefficient.
Case B	300 watt	14	22 x 50	0.27	light	medium	radial wave	good	Arrangement satisfactory, adeqnate intensity, well maintained, reflector suitable.
Case C	100 watt	12	22 x 35	0.13	light	light	dome	fair	Illumination adequate for the particular conditions of this freight station.
Case D	100 watt	12	25 x 40	0.10	dark	dark	dome	fair	Spacing slightly too great, otherwise acceptable with better maintenance.
Case E	25 and 40 watt	10	—	—	dark	dark	none	poor	No general lighting provided these lamps serving merely as markers.
Case F	60-watt carbon	8	—	—	dark	dark	none	poor	Lamps inefficient, no reflector, arrangement poor.
Case G	100 and 200 watt	11	—	0.24 ave.	dark	dark	dome and none	very dirty	No regular arrangement, poorly maintained, effect generally unsatisfactory.
Case H	100 watt	10	20 x 20	0.25	dark	dark	dome	good	Well laid out, good reflectors, results would be better with painting.
Case I	100 watt	9	30 x 35	0 10	dark	light	dome	fair	Spacing too wide, hence intensity low, otherwise satisfactory.
Case J	25 and 40 watt 3 light cluster	10	30 x 35	0.10	light	light	dome	poor	Generally unsuited.

sageways, aisles, storage spaces, etc. This value takes care of the safety element alone and is not intended to represent the most economical intensity, the code itself recommending that a higher intensity be provided.

In most instances lamps should be hung as high as possible. Properly applied, this does not reduce the average intensity of illumination, in spite of the popular misconception to the contrary. Lamps well up toward the ceiling are not so likely to be broken. In this position they are handled less and reflectors do not become so dirty. Light sources hung low or in the line of view may blind one temporarily and cause him to stumble.

All light sources of an efficient type are too bright to be viewed for any length of time. They require an accessory in the form of a diffusing globe or reflector, which together with proper placement, protects the eyes. In the class of building under consideration, it is generally the best practice to utilize open reflectors, in order to get the maximum illumination with the minimum expenditure of energy. The element of decoration or artistic appearance, beyond neatness, is, of course, not an important feature.

A reflector has the further advantage of directing the light efficiently where it is needed, rather than allowing a large portion to escape to the ceiling and walls. A given area can be adequately lighted with from 25 to 40 per cent. less power if lamps are equipped with reflectors, rather than used bare.

As pointed out before, it is most desirable to have walls and ceilings light in color. Paint is a wonderful adjunct to the lighting system. Many a poorly lighted room has been made satisfactory by refinishing the interior. This point cannot be emphasized too strongly in these days of coal conservation.

After the system is properly installed, it should not be neglected. It is most necessary to have a careful system of regular maintenance. This feature seems to be generally neglected in freight terminals. Any railroad man certainly knows that his roadbed would not be safe if it were not regularly inspected and kept in first-class condition. A pier would soon fall to pieces if the spiles were not renewed when broken or rotted. On the other hand, lighting equipment is allowed to fall to pieces, lamps to

become broken, reflectors rusty and very little attention is paid. The output of light is decreased considerably, even with a small layer of dust or dirt, yet many installations are in operation where equipment has been neglected for years. Certainly the user is receiving but a very very small percentage of the light he is paying for.

CHOICE OF THE SIZE OF LAMP.

As a general rule, the larger lamps are more efficient and cost less per unit of illumination than small lamps. The fewer the number of outlets, the less the cost of wiring and maintenance. On the other hand, in designing an installation a consideration of this feature alone may make the lighting practically worthless. For example, an area of 4,000 square feet is to be lighted. If ¼ watt per square foot is provided, 1,000 watts are needed. For ordinary ceiling heights, one 1,000-watt lamp would certainly not be the type to employ.

The size of the lamp is controlled primarily by the ceiling height. In other words, lamps hung 20 feet above the floor on 20-foot centers give the same results as lamps 10 feet above the floor on 10-foot centers. All other items being equal, mind this statement, a 400-watt lamp 20 feet high would be as effective as four 100-watt lamps 10 feet high.

Other items to consider are (*a*) Obstructions of various sorts. If material is piled high or if there is much piping, cross beams, etc., it is apparent that dense shadows would be cast by large lamps widely spaced, which could be avoided using small lamps spaced more closely together. (*b*) Character of ceiling, walls and general surroundings. If these are light in color, reflecting well, then considerable diffuse light is introduced in the illumination. This eliminates shadows and permits wider spacing. (*c*) Size of bay. The total area is usually divided into bays by posts or columns and for good appearance, as well as ease of construction, it is desirable to install outlets symmetrically with respect to the bays. This, of course, has a determining effect on the spacing and hence on the size of lamps. This practice is particularly important in warehouses where material is piled or stored in reference to the arrangement of posts.

CHOICE OF A REFLECTOR

The question of decorative appearance is not very important in the class of building under consideration. The object is to get the maximum light on the floor and hence on the material with the least expenditure of energy. An efficient reflector is essential.

In general, glass reflectors are not well suited for this type of interior on account of the likelihood of their being broken. Freight handlers are none too gentle in their methods and in carrying high pieces, lengths of pipes, etc., no particular pains will be taken to clear the reflector. An efficient steel reflector is generally the solution.

The dome type reflector gives a greater spread of light than the deep bowl, permitting wide spacing without intervening areas in darkness. This style also gives a higher output.

The dirty surroundings have been mentioned before and the surface of the reflector should be such that it can be easily cleaned. Porcelain enamel is virtually a layer of glass applied to the steel base and has all the advantages of glass. It is easy to clean, soap and water or even a wet rag will give the porcelain a bright, clean surface, returning it to its original efficiency, even though it has become greasy or very dirty. It resists acid fumes, whereas other finishes are likely to deteriorate rapidly if exposed to certain vapors. Being heat resistant, it does not depreciate nor turn yellow with age. It has a high reflecting power.

All enameled surfaces are not equally efficient. Good enameling appears a pure white or possibly a trifle yellow. A thin coating of enamel appears slightly blue, due sometimes to the base metal showing through. Reflectors with a surface having a slight bluish tint are by no means as efficient as those pure white. The enamel should be evenly distributed and there should be no cracks, however small. Moisture will creep through minute cracks and finally attack the base metal. The enamel should not be extremely brittle, as this chips too readily on being struck. In reflectors to be used out of doors, particular attention should be paid to the enameling around the joints, for these are most susceptible to rusting.

The leading manufacturers of industrial lighting reflectors have now standardized on certain shapes, sizes and quality of reflec-

tors. A constant check is kept on this latter item and a purchaser obtaining a reflector with the label of approval attached need have no hesitancy as to the items outlined above. The standardization referred to marks a big step forward in "Quality Lighting."

WAREHOUSES, EXPRESS AND FREIGHT STATIONS.

The light should be quite evenly distributed, as labels and markings must be read anywhere about the floor, yet the demands in this respect are by no means as exacting as where close visual work must be carried on. The intensity should be highest near the doorway and down the main aisles, for here is found the densest traffic. To attain an average intensity of at least 1 foot-candle and not have the minimum at the extreme sides or corners of the room appreciably below ¼ foot-candle, specified by the industrial codes, from 0.15 to 0.25 watt per square foot of floor area is advisable.* This figure presumes the use of high efficiency lamps and suitable reflectors and takes into account an average amount of acquired depreciation, which is rather high in the class of building under consideration.

The following general rules on maximum desirable spacing apply:

Ceiling 10 feet or less	16 feet
Ceiling 10 to 15 feet	20 feet
Ceiling above 15 feet	30 feet

Of course, these are subject to more or less variation, depending on the manner in which material is stored.

For long, narrow rooms (less than 30 feet or approximately one bay wide), one central row of outlets will serve the purpose well. Seventy-five-watt tungsten filament gas-filled (Mazda C) lamps in enameled dome reflectors on 15-foot centers would be a typical installation for a room with a 10-foot ceiling, whereas 100-watt units on 20-foot centers could be used if the ceiling were 15 feet.

If the room is wider, it is well to space outlets symmetrically in the bays. For example, a warehouse from 40 to 60 feet wide should have two rows of lighting units, while one over 60 feet will probably require three rows.

*Although the authors have endeavored to make the treatment as general as possible and applicable to any modern illuminant, it has been found expedient in the interest of simplicity and definiteness to base recommendations as to units, accessories and power on the Mazda C lamp, unless otherwise noted.

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Fig. 1.—Splendidly illuminated warehouse of modern construction. One [illegible]-watt tungsten filament gas-filled (Mazda C) lamp in enameled dome reflector is placed close to the 15-foot ceiling in each 20-foot bay.

Fig. 2. Day view in a warehouse which has an excellent illumination system. The rooms are divided into bays by columns on centers [illegible] feet. Each bay is provided with two outlets. Sixty-watt tungsten filament (Mazda) lamps in deep bowl intensive aluminum finish reflectors are placed close to the [illegible] ceiling. All wiring is done in conduit and rows of lights are controlled by snap switches which are located in the boxes shown on the columns in the foreground.

Fig. 3.—Night view of a loading platform 220 feet long, lighted by five 300-watt tungsten filament gas-filled (Mazda C) units. These lamps are enclosed in opalescent diffusing globes and are suspended close to the 16-foot ceiling. The intensity of illumination is high and the light colored surroundings reflect the light and cause it to be quite evenly distributed.

Fig. 6.—Night view of the delivery platform of a large railroad pier. This is illuminated by 200-watt bowl frosted tungsten filament gas-filled (Mazda C) lamps with dome shaped enameled steel reflectors, hung well out of reach. Certainly trucking and freight handling can be carried on with expediency under such illumination.

With ceilings averaging 15 feet, one outlet in the center of each 20-foot standard bay is excellent practice, as shown in Fig. 1. Where material is piled almost to the ceiling, it is necessary to localize units with reference to the aisles, as pictured in Fig. 2.

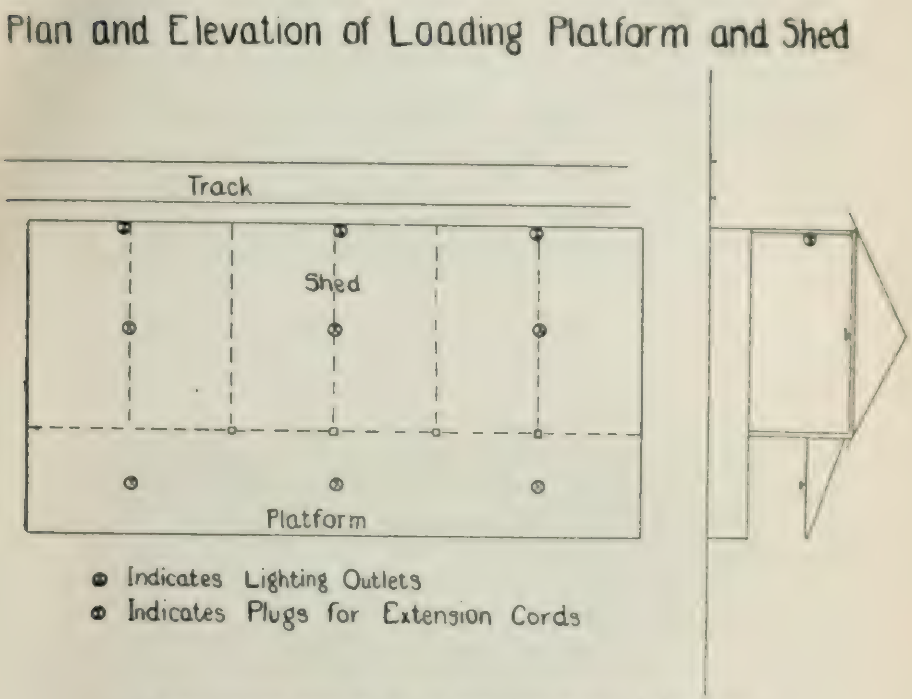

Fig. 4.—Diagram showing lighting layout typical small freight shed

For the loading platforms similar units and rules as to spacing apply. A particularly well lighted platform of this character is shown in Fig. 3. Where units are exposed to the elements, attention must be paid to the weather proof qualities.

To provide for the lighting of cars which are to be unloaded or loaded, socket receptacles should be installed on the pillars near the track side of the warehouse or station. In some cases these are installed along the track edge of the platform, slightly below the level of the car doors. This practice has certain ad-

vantages in that a shorter cord will suffice and the wiring does not interfere with trucking.

Extension cords with suitable sockets and lamps with wire guard should be available for use inside of the cars. The lamp guards can well have a hook arrangement so that the units may be hung from the ceiling rods in the car. A typical layout for a small freight or express shed with loading platform is given in Fig. 4.

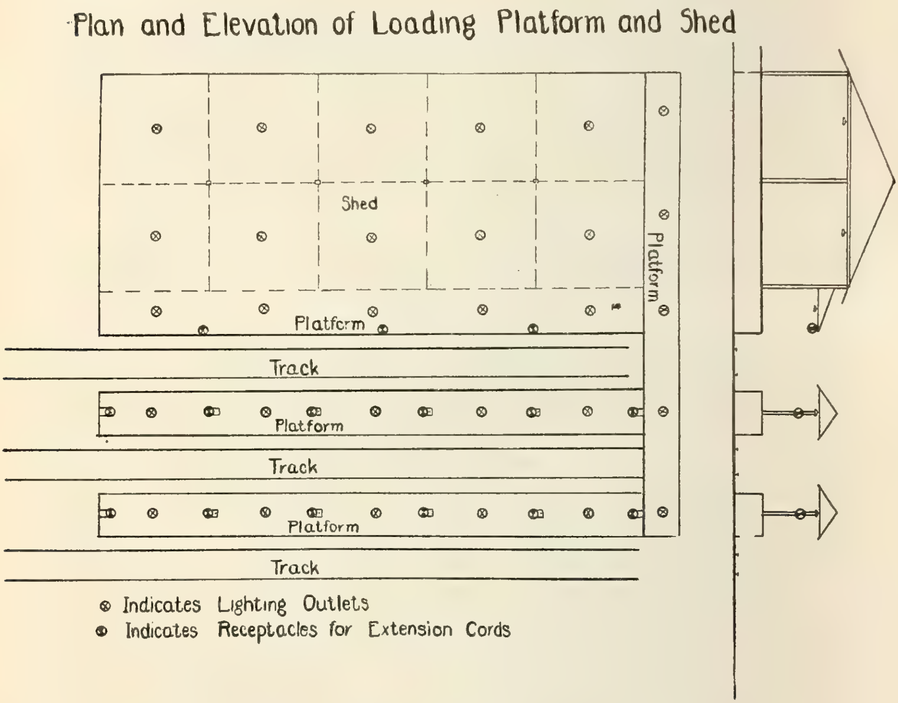

Fig. 5.—Diagram of lighting layout, typical transfer platforms.

TRANSFER PLATFORMS.

Well lighted transfer platforms promote safety of trucking and facilitate the handling of freight and express between the freight houses and express platforms, and the cars on the outside tracks. Absence of light here is a contributing cause to the placing of freight in the wrong cars, for a great deal of this work is done at night.

Fig. 7.—Night view of a coastwise steamship pier illuminated by [illegible]-watt tungsten filament gas-filled (Mazda) lamps in dome type enameled reflectors hung close to the roof trusses. Slightly over one-quarter watt per square foot thus supplied furnishes illumination adequately for safety and efficient freight handling.

Fig. 9.—Night view of the hot room of a Philadelphia fruit pier lighted by [illegible]-watt bowl frosted tungsten filament gas-filled (Mazda C) lamps with enameled dome reflectors. These are spaced so that approximately one third watt per square foot is provided. This produces an average illumination in the neighborhood of two foot-candles.

Fig. 10.—Night view of the passenger section of the Chicago Municipal Pier. This is 2340 feet long. A total of 236,400-watt tungsten filament gas-filled (Mazda C) lamps in opalescent enclosing globes are hung 25 feet high. These are on centers 40 x 35 feet. The freight section is located on the floor below. This is of equal dimension, but with a somewhat lower ceiling. Similar equipment and spacing is installed.

Fig. 11.—On account of the density of trucking and traffic in the neighborhood of a pier, it is desirable to have good illumination for all adjoining arrears. This night view, taken down the center of the Commonwealth Fish Pier, Boston, shows the effects of using 750-watt tungsten filament gas-filled (Mazda C) lamps in street lighting fixtures of the diffusing type. The lighting units are supported on brackets extending from the face of the building.

These platforms are generally long and narrow, being merely the space between adjacent tracks. Some are covered and others uncovered. For the covered platforms, units should be located midway between supporting posts, or if the posts are very close together, in each second section. If the platforms are uncovered, a central row of posts should be provided which will support weather proof lighting units on simple bracket arms.

For this work, a relatively flat reflector is most suitable, for not only must there be light on the ground, but also on vertical surfaces, as the freight checkers must compare stub tickets given them in the warehouses, with similar tickets placed on the sides of the cars, for which the freight is intended.

It is difficult to state exactly what size of lamp should be used, as this depends largely on the spacing. Seventy-five-watt units on 15-foot centers, 100-watt units on 20-foot centers, 150-watt units on 30-foot centers should prove satisfactory. If, in the case of uncovered platforms, the poles are spaced as far apart as 40 feet, it is then well to use two units per pole, one on each side in the plane of the center line of the platform. This is necessary on account of the heavy shadow which would otherwise be cast by the pole. Whatever unit is used, it should be supported rigidly to prevent its swinging in the wind. It is also well to provide receptacles for extension cords in weather proof boxes on the pillars. A typical series of loading platforms is illustrated in Fig. 5.

PIERS.

The annual carrying capacity of a vessel depends, to a considerable degree, upon prompt loading and unloading, so that it is good practice to work night and day when it is at dock.

Due to conditions over which man has no control, such as stormy weather, fog, ice floes and accidents, a fleet of ships cannot maintain any absolutely definite schedule as a railroad, and these unavoidable losses of time must be made up. A good lighting system must be maintained in order that the work may be performed efficiently during the dark hours. With poor lighting, no matter how good the mechanical equipment may be, the human element cannot work rapidly and the docking time will be lengthened. The general effects of good lighting, as outlined in the

opening paragraphs, are of course found on the pier and it will speed up the handling of material.

It is further necessary to provide adequate light for the custom officers to properly inspect all freight and baggage in the shortest possible time. The amount of material being handled by the shipping concerns at the present time is greater than ever before, making this subject of vital importance. It is reasonable to estimate that at least one-third of the work is done after night time.

There are two general classes of ocean and lake piers, the first, those used for both passenger and freight, the second, those used for the handling of freight only. As a rule, the larger piers of the first class are of the double-deck type, passenger section above, while the freight pier is usually only one story in height. Many river piers are similar in structure to railway freight platforms and should be lighted in the same manner.

All piers are long, narrow structures, the sides of which consist of doors through which the freight is passed. The center of the main dock is employed as a driveway for trucks and wagons. Since the freight is loaded from the sides of the piers, more light is required here than over the center, a low intensity sufficing for the trucking. The requirements for the sides of the pier correspond largely with those for a warehouse or freight station. The stevedores must read the addresses and place the hoisting tackle around the boxes, bales and casks to be loaded. Lamps should be hung high so that they will not interfere with the storage of freight, will not be broken and so that piles of freight will not cast long shadows. It is often advisable, in the case of a relatively low ceiling, to hang lamps between the girders rather than on them. This permits a slightly higher hanging.

For piers handling general freight and merchandise, the rules for spacing and size of lamps given under warehouses apply for the side bays or loading sections; approximately ¼ watt per square foot will give adequate lighting. For the trucking area or center bay, larger lamps can be used on wider spacings. A general figure of ⅛ watt per square foot will prove satisfactory. A typical loading platform or side bay well lighted in accordance with the rules laid down is shown in night view, Fig. 6.

Where the pier is relatively narrow with no line of demarka-

tion between the loading areas and the general trucking space, as illustrated in Fig. 7, a symmetrical arrangement of outlets over the entire area best meets the conditions. The diagram, Fig. 8, however, shows an arrangement commonly encountered. For these particular dimensions, 150-watt lamps in enameled dome steel reflectors should be used, one each in the side bays, while 300-watt units of the same character on 50-foot centers furnish adequate light for the central or trucking space.

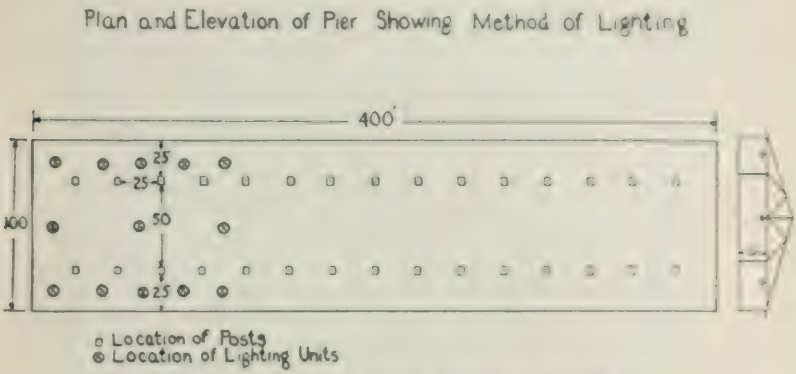

Fig. 8.—Diagram showing typical freight pier lighting layout.

For piers devoted to the handling of fruit, the lighting requirements are considerably more exacting. A higher intensity is required and more even distribution. Fruit after being unloaded on the pier is generally sold at auction. The commission merchants visit the piers and inspect the fruit. It is quite important that the true condition of the fruit be shown to the prospective buyer. It is necessary that the color of the fruit is not distorted and a close approximation to white light is desirable for the artificial illumination. A case is on record where commission merchants have refused perfectly good fruit and left it to rot on the hands of the owners, because it appeared green under artificial light, the color composition of which was such as to distort materially the natural appearance.

From 0.3 to 0.5 watts per square foot is desirable for a fruit pier. A fruit pier equipped as outlined is illustrated in Fig. 9.

In the passenger decks of the pier, somewhat more attention should be given to the appearance of the unit. Most people who

travel by boat, for business or pleasure, are of a class which are accustomed to the comforts resultant from good artificial illumination. The patronage of this class of people is most desirable in normal times and a well lighted pier is a factor toward this end. With good lighting the inspection of baggage by the custom officers is facilitated, which tends to eliminate one of the greatest inconveniences of ocean travel. A well equipped and thoroughly modern passenger deck is pictured in Fig. 10.

The traffic in the neighborhood of a busy pier is quite heavy. To avoid confusion and resultant delay of trucking, the approaches to a busy pier should have somewhat better lighting than normally furnished by the municipal street lamps. Standards are quite out of the question, as they are very likely to be broken by a truck. Brackets suspended from the face of the building provide the logical solution. Standard street lighting equipment of the various types, with their particular advantages, should be used here. The quality of light or the size and spacing of units is a matter that is somewhat out of the province of this paper and governed largely by local conditions. An excellent example of this form of lighting is shown in Fig. 11.

A completely equipped pier should have high powered lamps on the water side of the structure. These should be hung high so that the open hatchways of the ships will be or can be lighted. This facilitates the freight handling and tends to eliminate accident. The actual lighting of the hatchway itself is taken care of by portable lamps, which are part of the ship's equipment. The external lighting of the pier is a great protective agency.

The importance of protective lighting has been emphasized in a number of papers before the Society. Shipping is a very vulnerable part of our war activities. The methods outlined for protective lighting of any building apply equally well to the pier. Lamps suspended from the face of the building in a case of a pier should be supplemented by searchlights and floodlights, which are adjustable and can be used to sweep the surrounding waters. Care must be taken to see that these units are so arranged that approaching and passing pilots are not blinded by glaring beams. Practically all the large piers have this type of equipment now installed. It is inexpedient to go into details as to its construction or application.

CONCLUSION

It must be borne in mind that a difference exists between freight handling and ordinary manufacturing processes. In the latter, it is possible to install automatic machinery and so plan the work that undue congestion does not result. From the very nature of freight handling, practically all work is manual and rapidity of movement is essential to prevent delays and resultant tying up of traffic. The demand for proper artificial lighting is acute.

While this is true in the case of railroad freight it applies even more forcibly to the ship. If a freight car is held over, only one small unit of a huge system is out of service. If a vessel is delayed, entire investment lies useless and its crew's wages go on without yielding any return.

It is believed that the case for good lighting has been proven. Improper or inadequate illumination increases the cost per ton of handling freight. Since the capacity of a warehouse is dependent on the speed with which material moves through it, bad lighting reduces the capacity. It is certain that it decreases the number of working hours.

Conversation with agents in charge of poorly lighted stations and warehouses indicates that they realize that the cause of many mis-sent shipments is lack of proper lighting.

Accidents are increased with darkness. The cost of an accident in damages may be many times the cost of properly lighting a station, warehouse or pier for a long period.

DISCUSSION.

ROGER O. ACKERMAN, Chief Electrician, C. & R. Division, Army Transport Service: I was greatly interested in the remarks about the piers. On Piers 95, 96, 97 and 86, New York, the gooseneck fixtures mounted on the sides of the piers and described by the previous speaker, proved unsatisfactory; first because of their being broken very often by the ships' booms while loading; and second, because from a lighting standpoint they are insufficient. We found that the light from the goosenecks had to be supplemented by cargo clusters on the ships' decks, which means that light is being furnished from two sources

to accomplish the same result. As Chief Electrician of the Army Transport Service, I had charge of this equipment.

When I first took up my duties in Hoboken, the lighting external to the piers was obtained by the use of arc lamps. These were very inefficient and from a point about 100 feet from the pier appeared like blue dots along the sides of the piers, giving but little illumination. It was evident that steps had to be taken to decide upon and install some sort of flood lighting which would facilitate the handling and loading of the ships.

There were several conditions to be met in planning this lighting. These I will briefly mention:

First. The lighting had to be such as to not interfere with the pier signal lights or with navigation in the slips.

Second. Absence of glare.

Third. Simultaneous lighting of loading decks, hatches and pier string-pieces.

Fourth. Wide diffusion of light so as to make it go "around corners" so to speak.

Fifth. Reduction of deep shadows to a minimum.

Sixth. Different types of piers and pier sheds.

Seventh. Flexibility and durability of the lighting units.

Flood light projectors were finally installed. There was considerable discussion at the time as to whether the reflectors should be of glass or of highly polished metal; the latter was decided upon by those in authority ostensibly in the interests of economy. The flood light projector scheme is supplemented by the "Novalux" pendant unit put out by the General Electric Co., with the idea of wiping out shadows between the projector beams.

Experience, in my opinion, has shown that the flood light projector scheme is not the one best suited to our needs for the following reasons:

First. Considerable glare is present which, for men working along the edge of a ship's deck, is productive of considerable life hazard.

Second. With ships coming in "Light" the loading decks are often as high as 40 ft. above the water's surface. This condition leaves a very short working distance for the projectors as the top of the pier super-structures are only 65 ft. from the water.

Third. The projectors, in order to light the pier string-piece, have to be inclined to a point where the life of the lamp is endangered. Sharp deep shadows are thrown on the decks on account of the many obstructions, booms, winches and all kinds of tackle found thereon.

Fourth. The vaunted flexibility of the projector, as far as concentration of light is concerned, is a design point of which we would take no advantage due to the inaccessibility of the units on each roof or superstructure and the number of piers to be cared for.

Fifth. The manufacturers should make greater efforts to render their projectors weatherproof. Already we have had to touch up the units we installed with red lead.

Sixth. The metal reflectors in the projectors have failed to stand up under the attacks of weather, smoke gas and salt water and are now absolutely useless.

In conclusion, I might say that the best scheme to meet our all 'round conditions would be the installation of the pendant unit, equipped with a reflecting glass surface on one side. This unit then would throw the light out from the pier, eliminating the waste over the pier roof and down along the string-piece.

G. H. Stickney: While the rapid handling of freight is not so vital as it was before the signing of the armistice, it is still one of the limiting factors in the industrial life of the country, and therefore is still of fundamental importance.

The investigations show that the lighting commonly employed is far below that desirable for economy and efficiency, as well as the safety of the workers.

Enlarged terminals mean not only larger investments, but also longer carries, so that increased capacity brought about by better lighting is doubly advantageous. Because of the large amount of hand labor involved and the frequent necessity of rapid work, the cost is relatively large and the savings possible with adequate illumination very considerable.

The intensities recommended in the paper are quite modest.

and it is highly probable that the maximum of over-all economy would make considerably higher intensities desirable. I feel certain that demonstrations paralleling those on machine shop lighting, recently run in Chicago, would confirm this view.

The workmen themselves realize that they are working under a handicap, but are not in a position to realize or evaluate the advantages of good illumination.

If through this paper or otherwise those in authority can be interested in the problem and induced to investigate, a very considerable improvement in these classes of lighting should result.

E. E. Dorting (Interborough Rapid Transit Company): Mr. Powell has clearly illustrated the necessity of keeping lamps and reflectors clean in order to obtain efficient results.

I believe that he should have mentioned the additional feature of employing some means of raising or lowering these units probably by an automatic cut-out.

It has been the practice of our company to use an automatic cut-out on all units mounted 20′ or higher from the floor. We thereby eliminate the hazard of using ladders and also insure a frequent inspection. These cut-outs can be purchased at a very small cost (approximately $4.00 each) and being ruggedly constructed will last a number of years.

Another point worth mentioning is that the rope or chain running from the floor to the cut-out should be fastened by a lock which will allow only the holder of the key to lower these units.

M. G. Lloyd (Bureau of Standards): I do not think I can add anything at all to this subject in a technical way. I am greatly pleased to see it so thoroughly investigated, the data gathered from actual conditions and good practice set forth here for the benefit of those who are in a position to apply it. When the matter is put before the proper authorities in charge of piers and freight stations, they can hardly hesitate to install good lighting when it means such a financial advantage and saving of time. Lighting is such an important factor from the standpoint of safety, in avoiding accidents of all kinds, that it is usually worth while to provide good light simply on that account. However, one does not need so high an intensity to

avoid accidents as to do good work where it is necessary to read labels.

It is very often surprising to me to find how backward certain industries are in the matter of illumination. It is not very hard to show that the concerns involved are losing money right along because they are backward in that respect. We can only attribute such a condition to the fact that the matter has not come to their attention. They do not realize what the conditions are and how they may be improved. That is where I think the Society has done a good thing in bringing such matters to the surface and to the attention of people who ought to know a great deal more about them.

W. T. Blackwell: In talking to Mr. Powell before presenting the paper, I told him that I thought I recognized many of the piers under discussion as I used to be with the City Government. I think I know the reason why only 6 2/10 per cent. had good illumination and that is due to the City's system of handling piers. All waterfront property is the property of the City; also piers and the pier sheds, and these are leased to various steamship and other companies and they maintain the equipment. When the lease expires, these bulkheads, piers, etc., are leased to the highest bidder. Naturally, the lessor will not spend any more money than he can help on the pier.

The trip that Mr. Powell covered in examining these piers represents the evolution of pier construction. I think you will find the pier shed having one story with hatchways at intervals on the side and so on until you get around to the Chelsea piers at 23d St., where the hatchways are continuous, and where you have skylights, ventilation, sprinkler systems, etc. I don't know whether it was their good fortune to see some of the more modern piers, for example—the one at the foot of West 56th St., or the one at West 57th St. Those are double-deckers and well lighted. There's another one, also, at 35th St., Brooklyn. This is also a well lighted pier, which was built to meet the demand of large ocean vessels.

There has been another factor too, that has more or less held back the progress of the City's shipping, insofar as docking facilities are concerned, owing to changes necessary in the bulkhead

lines, which had to be sanctioned by the United States Government. There is no doubt that there is lots of room for improvement in all the piers mentioned. There have been several attempts to do missionary work by lighting companies and some other companies of the city some of which have met with success and others with no success.

With reference to the other part of the paper in regard to warehouses, I should like to point out that there is a class of warehouse which in the insurance terminology is known as "listed warehouse." The owner of the warehouse cannot store any material, as the rate is based on moral hazard. There is less danger of fire and consequently insurance companies can afford to allow a lower rate. Only recently have they permitted the use of electric lighting in listed warehouses. In those warehouses the Underwriters specification requires a fixture with a wire guard. Very few of those warehouses have been lighted, up-to-date. Those that are not lighted use sperm oil lanterns. Here is another chance for missionary work. There are many warehouses of this kind, very nearly 2,000 in New York and Brooklyn.

I believe we have some very interesting statistics in this paper and I certainly hope that the paper will reach the hands of the people who have charge of the piers. They are really the ones at fault.

A. L. Powell: It is rather interesting to note that while but little space in the paper was devoted to the lighting of the exterior of the pier, the discussion has brought up some most interesting concrete suggestions.

It is my opinion that, in general, floodlighting is not the proper method to use for most of these illumination problems. There are numerous obstructions which cast long, dense shadows, making working conditions dangerous. A close approximation to general illumination is desirable.

To light the deck of a ship at an isolated pier, weatherproof angle type reflectors and high candlepower lamps give a desirable distribution. These should, of course, be hung as high as practicable, as there is danger of their being struck by booms and broken. It may be well to make recesses or pockets in the face of the pier and place the units here.

Where piers are adjoining and two ships are to be lighted at the same time, a somewhat different method may be applied. A special unit of the street lighting type with a prismatic band refractor and exterior globe mirrored on one half, has proven useful. This equipment gives sufficient lighting near the pier. At the same time the broad band of light emitted through the refractor illumines the ship at the opposite pier and cuts shadows. The mirroring prevents waste of light in directions where it is not needed.

Some mention was made of the automatic cut-out as a necessary adjunct to a lighting system. This is a device, the value of which is not yet fully recognized. It provides a convenient and safe means of cleaning. We must, as a society, convince the operating departments of the necessity for careful and regular maintenance. There is more light wasted through the use of dirty lamps and reflectors than through any other cause.

In connection with the lighting of the interior of freight cars during loading periods, it has recently been reported that a combination of folding metal arms with a lamp has been successfully applied. These are attached to the platform and carried into the car when necessary. This scheme has the advantage of eliminating wear and attendant hazard of flexible or drop cords.

URBAN RAPID TRANSIT CAR LIGHTING.*

BY CLIFTON W. WILDER AND ALBERT E. ALLEN.

A study of the problem of urban rapid transit car lighting in New York City was undertaken by the authors in behalf of the Public Service Commission of the First District of New York. Proper car lighting became a problem in transportation with the advent of the rapid transit system in New York City where passenger trips underground of one-half hour and over twice a day form one of the habits of a large part of the population of the city.

This half hour or more spent in traveling is utilized very generally for reading the daily newspapers. The demand for ample and comfortable reading illumination has been emphasized over and over again by the public whenever such illumination has been lacking and we have come to consider illumination, which will satisfactorily meet this demand, as a necessity rather than a luxury.

To the engineer who has solved the complicated problems of illuminating theatres, large offices, banquet halls, etc., the illumination of a car 50 ft. long by 8 ft. wide and approximately 8 ft. high probably does not suggest at first sight any particular difficulties.

There are factors in car lighting, however, which are not encountered in the ordinary lighting problems, such as series lighting, five lamps to a circuit, voltage fluctuations between 60 and 100 per cent. of maximum, crowding of one hundred and seventy-five passengers onto a floor area of 400 sq. ft., forty-four of whom are seated and demand the right to read undisturbed while the standing passengers sway back and forth with the lurching of the car traveling at speeds of 45 miles an hour, etc.

Where the voltage of lighting circuits is practically constant and where no moving shadows interfere, a lighting intensity of 2 foot-candles on the reading plane will provide an illumination

* Paper prepared for presentation before the meeting of the New York Section of the Illuminating Engineering Society, New York, N. Y., January 9, 1919.

by which a person can read comfortably for short periods of time. If the illumination varies, however, between 2 and 4 foot-candles, for example, at frequent intervals or, if an intensity of 4 foot-candles is suddenly reduced to 2 foot-candles, difficulty or at least discomfort in reading will be experienced and such conditions will be a cause for complaint.

Our investigations of illumination in cars carrying passengers indicate that, due to the fluctuations and consequent contrasts, a minimum of 3 foot-candles is necessary for car lighting in order to avoid complaints from the traveling public.

The direct current voltage at the substation bus on the Interborough Rapid Transit system is 625 and averages about 585 volts at the car under economical operating conditions. The starting load of a ten-car train is approximately 4,000 amperes and of a six-car train 2,800 amperes. On a four-track subway section, operating ten-car expresses and six-car locals, the loads at the substation bus frequently vary by 10,000 amperes in short periods of time.

The momentary variations in substation voltage, due to these wide fluctuations in load, added to the drop in the feeders and return circuits, often result in a voltage at the operating car as low as 450.

It would appear at first sight that variations in voltage of this magnitude should be eliminated by the installation of additional copper. The heavy starting loads, however, are of very short duration, so that the power loss is small and, from an economical standpoint of power transmission, the installation of additional copper would not be warranted simply for the purpose of improving the illumination.

With electrical energy available for power purposes, battery lighting is, of course, out of the question and, because of the impracticability of 600-volt lamps, series lighting becomes necessary, utilizing standard lamps burning five in series.

The small cross-section of a car and the consequent low ceilings precludes the use of a few large units for lighting or the concentration of small units in clusters. It also necessitates

locating the lighting units at points where they are but a few feet from the eyes of passengers.

The intense brilliancy of the tungsten lamp located so close to the eye, it being only from 2 to 3 ft. distant in case of standing passengers, is extremely objectionable. The problem, therefore, is to obtain a satisfactory illumination, the source of which shall be, at least to a large extent, removed from the direct line of vision of passengers.

The lighting plan, as shown on Fig. 1, the units of which are 40-watt bare lamps, which scheme of illumination is most familiar to the patrons of the older New York subways, is the result of the development of the incandescent lamps rather than a study of illumination.

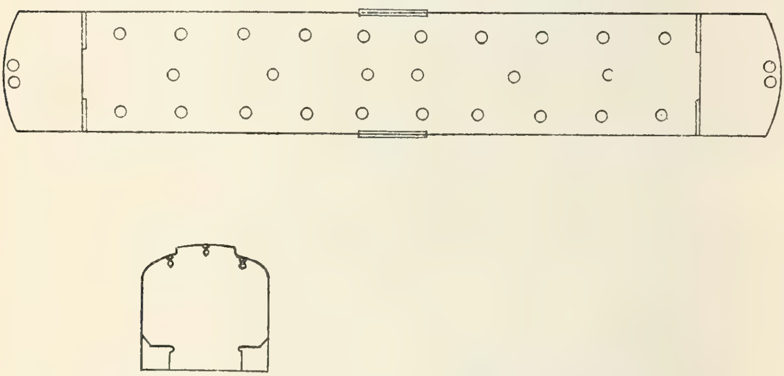

Fig. 1.—Original arrangement of lamps in Interborough Rapid Transit Company car.

The original subway car operating in New York City was lighted by 16-candlepower carbon lamps arranged as shown on Fig. 1. Five-car trains were utilized in the first operation, the starting loads of these trains amounting to about 1,950 amperes which, with the distribution system as installed, caused very little fluctuation in voltage. It was later decided that 16-candlepower lamps gave more illumination than was necessary and 10-candlepower lamps were substituted.

As the train schedules were increased and the trains were lengthened to eight cars, the starting loads began to very materially affect the lamp voltage, causing marked fluctuations and consequent wide variations in the illumination furnished by the

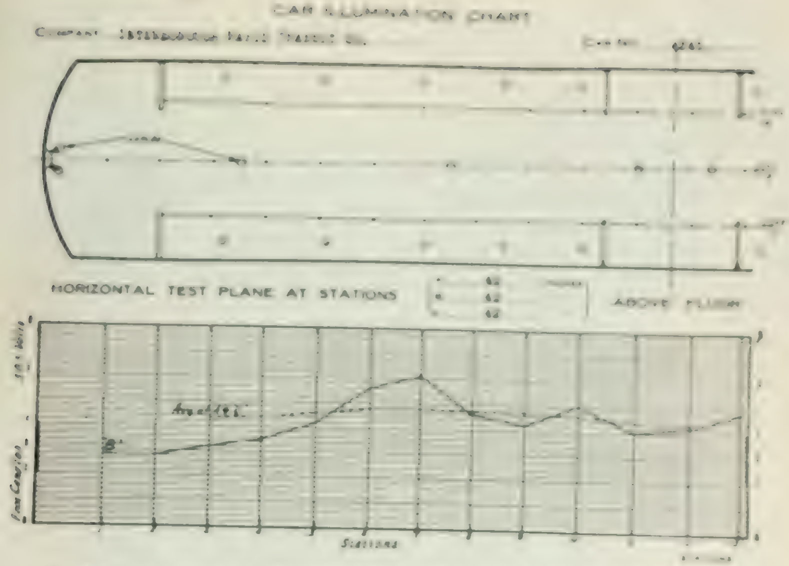

Fig. 5—Distribution of illumination on a plane 3½ feet above floor produced by lighting arrangement shown in Fig. 1 with [illegible]-watt tungsten lamps.

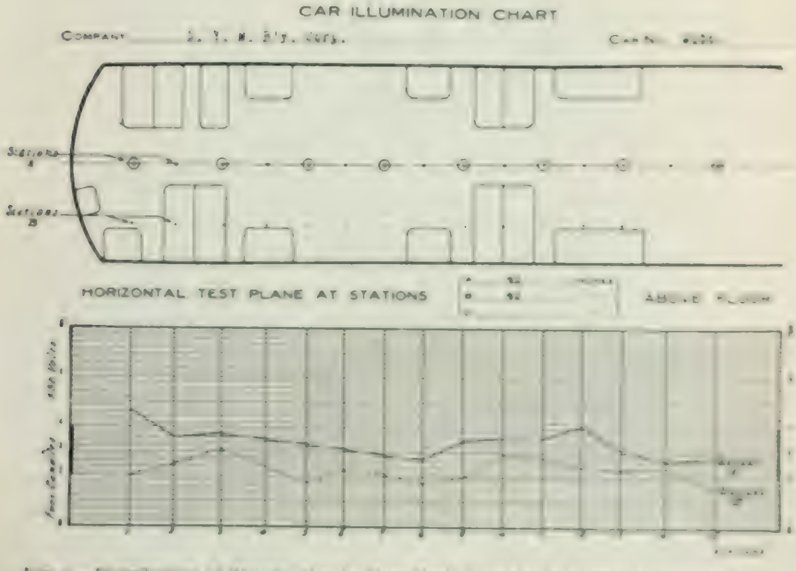

Fig. 6—Distribution of Illumination in New York Municipal Railway Corporation car

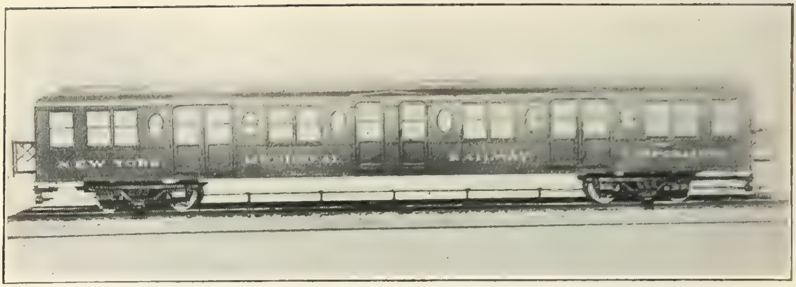

Fig. 4.—New York Municipal Railway Corporation car.

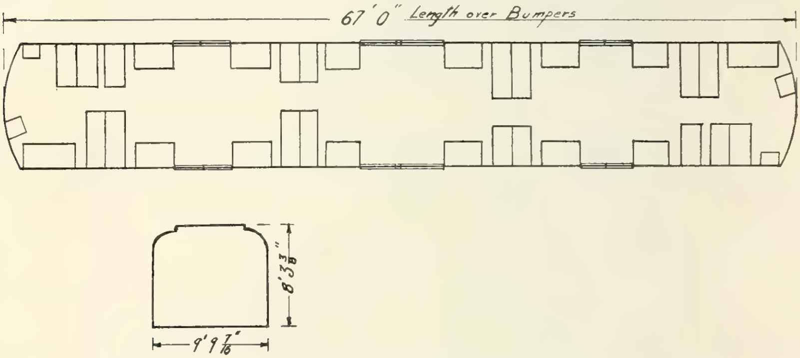

Fig. 6.—Dimensions of New York Municipal Railway Corporation car.

Fig. 11.—Interborough Rapid Transit car.

10-candlepower carbon lamps. The fluctuations in voltage throughout a typical run on a rapid transit line, as obtained by observations at one half minute intervals, are shown on Fig. 2 and, also, the corresponding variations in candlepower of a carbon and a tungsten lamp. To improve this condition, the 16-candlepower lamps were reinstalled, but the added illumination did not suffice as the voltage fluctuations were increasing.

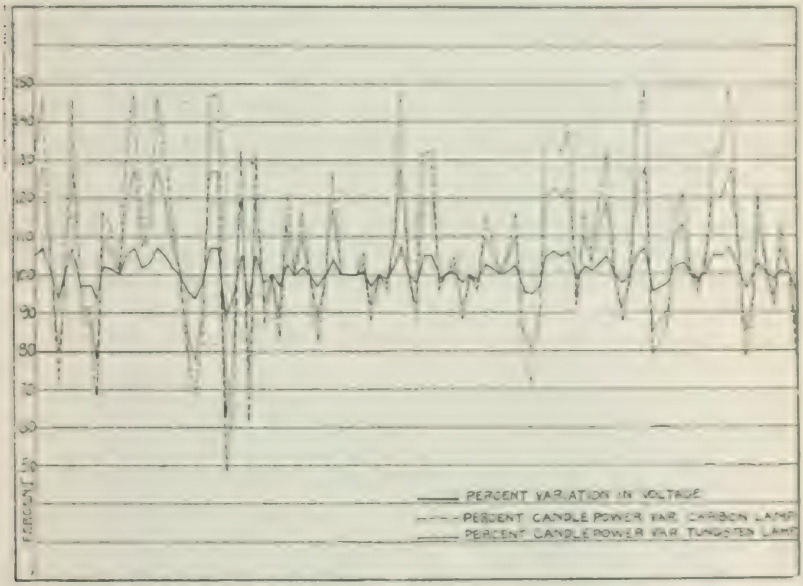

Fig. 2.—Voltage fluctions throughout typical run, with corresponding candlepower changes.

The Interborough Rapid Transit Company made some experiments with tantalum lamps, but before the experiments were concluded, the drawn wire tungsten lamp became available and its superiority over the tantalum lamp was evident immediately. The reduced fluctions in illumination obtained by the use of the tungsten lamp in place of the carbon lamp is indicated by the light line on Fig. 2.

The 40-watt lamp at that time was so much more rugged than the smaller size that it proved to be the most economical. This size of lamp provided over twice the illumination that was originally considered necessary, but it was not deemed advisable to

rewire the cars for a lesser number of units inasmuch as the power consumption of the tungsten lamps was less than that of the carbon lamps.

The lighting arrangement shown on Fig. 1 with 39-watt tungsten lamps provides 2.7 watts per square foot of floor area at the average operating voltage of 585 and, with white ceilings, supplies an average of 4.5 foot-candles on a reading plane 3½ ft. above the floor. Fig. 3 shows the actual distribution of illumination on a plane 3½ ft. above the floor. The illumination intensity on any plane above the reading plane of a seated passenger is considerably greater than this and the total lumens in the car is far above anything that is necessary to provide a reasonable and cheerful illumination.

In the Dual Subway Contracts, known as Contracts Nos. 3 and 4, between the City of New York and the Interborough Rapid Transit Company and the New York Municipal Railway Corporation, it specified that "The equipment provided for initial operation shall be of the best character known to the art of urban railway operation."

The New York Municipal Railway Corporation, pursuant to this requirement, undertook to design a car which should be the latest word in car construction in every detail. The result was a type of car radically different from anything previously used in railroad operation.

A very exhaustive study was made of the possibilities of illumination for this type of car, results of which were presented to this Society in a paper entitled "A Practical Study of Car Lighting Problems" by W. G. Gove, Engineer of Car Equipment of the New York Municipal Railway Corporation, and L. C. Porter of the General Electric Company, printed in the TRANSACTIONS of the Illuminating Engineering Society, 1915, Vol. X, p. 227.

The exterior and interior views of the Municipal car are reproduced here in Figs. 4 and 5 and the general dimensions in Fig. 6, in order to place the general picture of the car before the meeting during this discussion.

The New York Municipal Railway Corporation adopted a lighting unit consisting of a 56-watt half-frosted lamp set in a 6-inch Sudan glass reflector, which will be seen in Fig. 7. Fifteen

Fig. [illegible]—Interior of New York Municipal Railway Corporation car.

Fig. [illegible]—Interior view of New York Municipal Railway Corporation car showing type of fixture used.

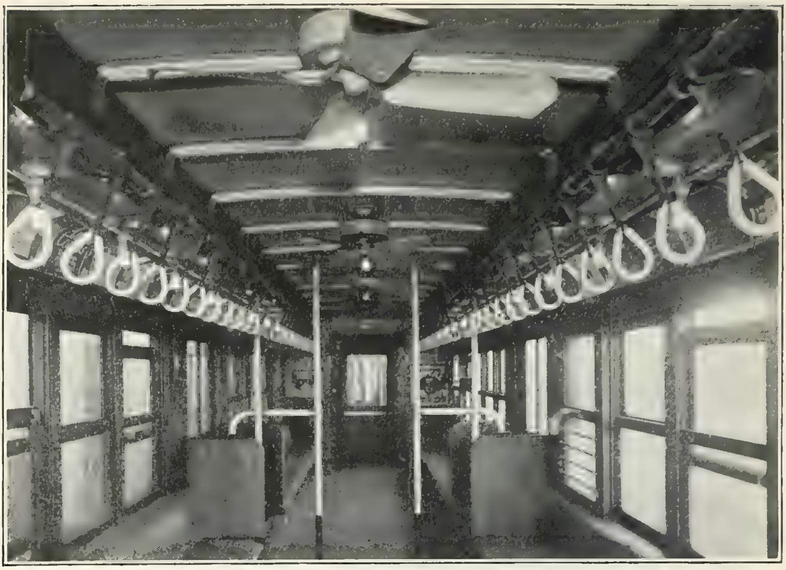

Fig. 12.—Interior of Interborough Rapid Transit car fiitted with bare lamps.

Fig. 14.—Arrangement of lighting units. Interborough Rapid Transit car equipped with reflector units.

of these units were installed along the center line of the car ceiling as shown in Fig. 8. On Fig. 9 will be seen the distribution of illumination resulting from this installation as the cars were finally put in operation, the side walls of the car having been changed to dark green. The walls in the model car, used in testing the various types of illumination, as set forth in the paper already referred to, were gray from the floor to the window-sills and white from the window-sills to the roof.

The cars of the New York Municipal Railway Corporation are at present operating on two voltages. Power is supplied in Brooklyn from the stations of the Brooklyn Rapid Transit Company at 600 volts and from the stations of the Interborough Rapid Transit Company, in Manhattan, at 625 volts.

At the average lamp voltage in Brooklyn, which is approximately 550, this installation provides 1.32 watts per square foot of floor space.

Soon after the Municipal car was put in operation, complaints of inadequate illumination were received by the Public Service Commission. But little attention was paid to these first complaints as it was felt that the exhaustive study which had been made in selecting the type of illumination for this car left nothing further to be suggested. They continued, however, with such persistence that it was deemed advisable to determine accurately the conditions existing in operation and a series of observations were made with a Macbeth illuminator during the rush hours when the cars were carrying heavy standing loads. Twenty-four points in the car were found where the shadows cast by standing passengers reduced the illumination on the reading plane of seated passengers below 2 foot-candles, in some cases, as low as 0.5 foot-candle.

No reasonable increase in the size of the lamps would correct this condition, nor could a symmetrical rearrangement of the fifteen units be made which would provide a light distribution for the seating arrangement in this car which would eliminate these shadows.

It happens that agitator fans are to be installed in these cars and, as this is done, a rearrangement of the present units will be made and an additional circuit of five lamps will be added as shown by Fig. 10. At the average lamp voltage, this installation

with the 56-watt lamps provides 1.76 watts per square foot of floor area with a resulting distribution of illumination in the empty car, as shown in the same figure, Diagram A.

The irregular distribution of illumination would appear open to criticism. The actual results, however, are very satisfactory as will be seen from the curves in Diagram B, of the same figure, which shows the intensity of illumination on the reading planes of seated and standing passengers. The high peak at Stations 10 and 11 could be reduced and a slightly better curve obtained if lamps between Stations 9 and 12 were moved further apart, but these locations were made necessary by hand straps which are not shown on this diagram.

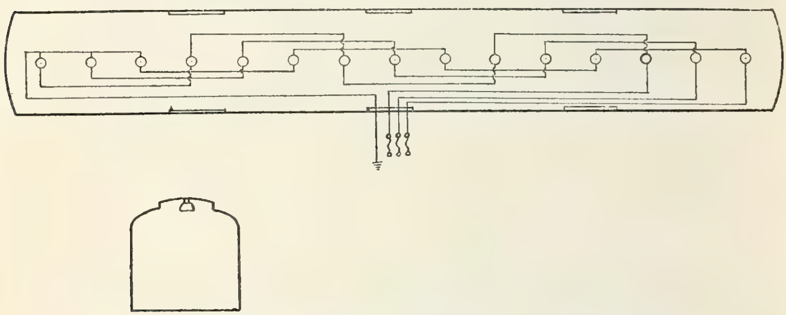

Fig. 8.—Arrangement of fixtures in New York Municipal Railway Corporation subway car.

In the near future, the average operating voltage in Brooklyn will be increased to about that of the voltage in Manhattan or 585. With a uniform voltage throughout the system, it is probable that twenty 40-watt lamps, arranged as already shown, will give ample illumination in this car. If this is correct, we will then have a rapid transit car with power consumption for lighting of 1.34 watts per square foot of floor area and an illumination on the reading plane of the seated passenger of approximately 4.0 foot-candles.

Leaving the text for a moment, the improved lighting design of the Interboro subway cars was developed by the engineers of that company.

An exterior view of the standard Interborough Rapid Transit car is shown on Fig. 11. The arrangement of the lamps according to the old standard is shown on Fig. 1 and the interior by photograph Fig. 12. The distribution of illumination obtained by this arrangement is shown on the curves in Fig. 3.

This arrangement provides 2.7 watts per square foot of floor area at the average operating voltage of 585.

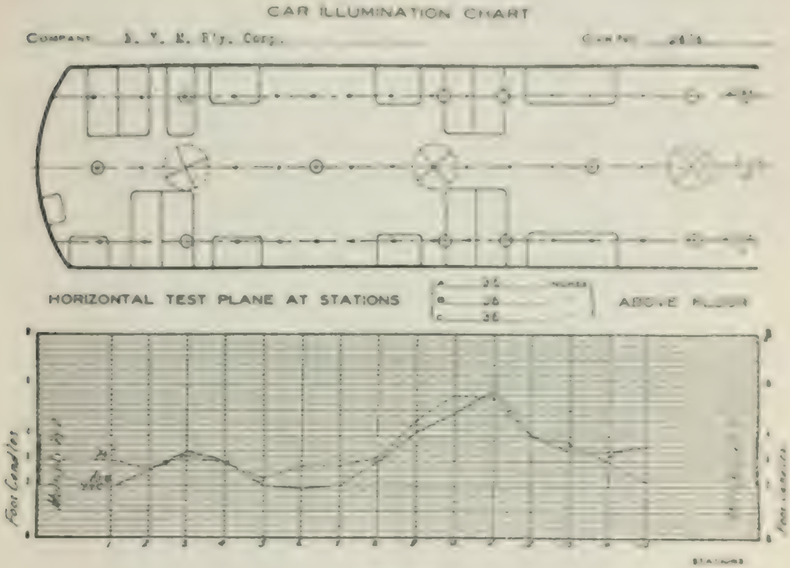

Fig. 10A.

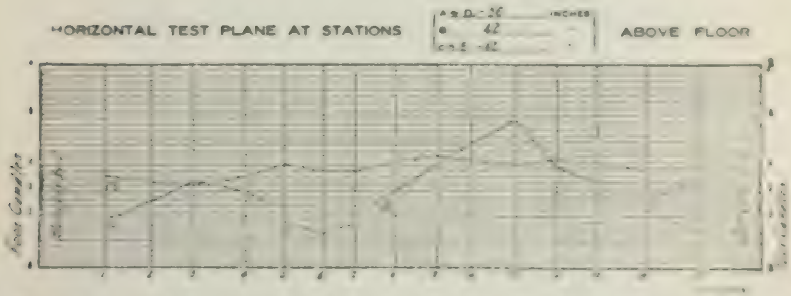

Fig. 10.—Proposed rearrangement of units in New York Municipal Railway Corporation car. (a) Distribution of illumination car empty. (b) Illumination intensity on reading planes of seated and standing passengers.

In redesigning the lighting of this car, it was apparent from the illumination curves in Fig. 3 and the very brilliant illumination throughout the car that a considerable reduction in the wattage could be made. In order to accomplish such a change without increasing the cost of installation, lamp costs or main-

tenance, it was necessary to reduce the number of units rather than the size of the lamps.

With a reflector designed to throw the light down as well as transmit some light horizontally, the logical lamps to eliminate were those along the center line of the ceiling. As there were six lamps in this location, it became necessary to eliminate one circuit of five lamps and find a satisfactory location for the sixth lamp or else eliminate two circuits. It was found that with the reflector selected two circuits could easily be eliminated, leaving sixteen units in the car and two in each vestibule.

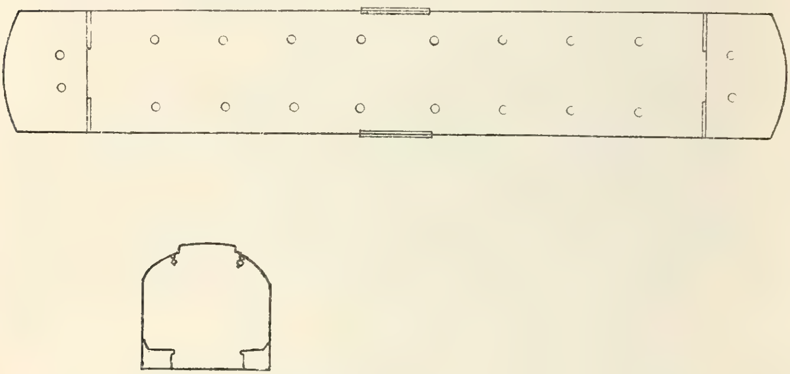

Fig. 13.—Arrangement of lighting units—Interborough Rapid Transit car equipped with bare lamps.

This arrangement of units is shown by Figs. 13 and 14 and the distribution of illumination by the curves in Fig. 15.

A modification of the reflector as originally tested, was finally adopted which provided a slightly better illumination on the reading plane of the seated passenger, but which did not transmit as much light in a horizontal plane. The distribution of illumination throughout the car with this type of reflector is shown by the curves in Fig. 16.

It was not long after this type of illumination was put in operation that the company controlling the advertising privileges in the cars complained of insufficient light to properly display the advertisements and that the value of the advertising privilege was considerably reduced because of that fact. As this privilege brings in a very considerable income to the operating company, such a complaint could not be disregarded.

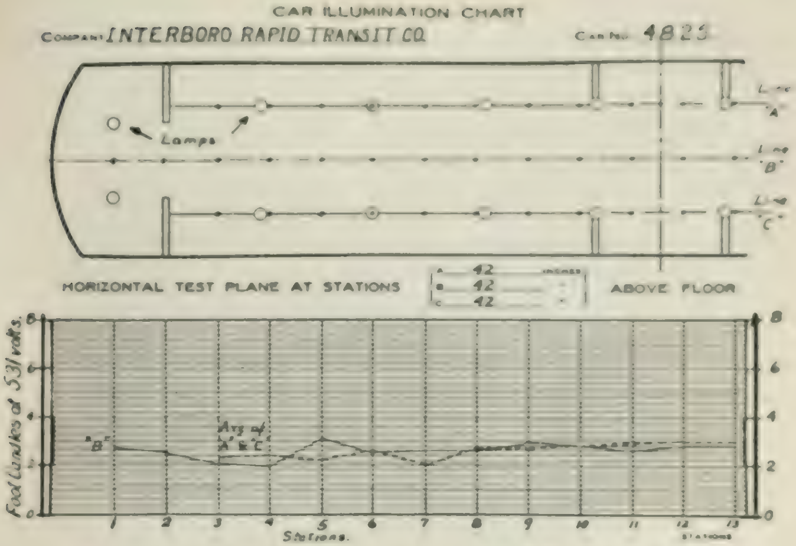

Fig. 15.—Distribution of illumination in Interborough Rapid Transit subway car fitted with bare lamps.

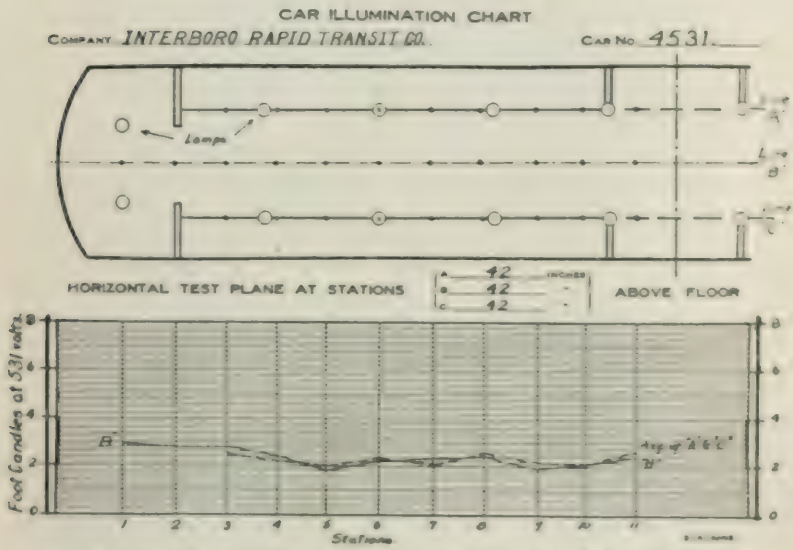

Fig. 16.—Distribution of illumination in Interborough Rapid Transit subway car fitted with Sudan reflector units.

The dust collecting on the shades and lamps which was inevitable during the recent shortage of labor caused an appreciable reduction in the available illumination, resulting in a very gloomy appearance in the car. This was particularly emphasized by the very brilliantly lighted cars equipped with the thirty bare lamps which operate frequently in the same trains.

It is the intention of the company to remove the reflectors now used and substitute a reflector similar to the one originally tested, which will greatly improve the general illumination of the interior of the car as well as provide a satisfactory reading illumination for passengers.

The Interborough Rapid Transit Company is operating approximately 1,500 cars and it is estimated that each car is in service on an average of about 12½ hours per day. The current consumption, therefore, for lighting, on the basis of the 30-lamp car would be 20,800 kilowatt hours per day, as compared with 13,900 kilowatt hours per day, if all cars were equipped with 20 lamps each. The Interborough Rapid Transit Company is at present generating its power on about 1.86 pounds of coal per kilowatt hour. At this rate, the saving of coal, due to the adoption of 20 lamps per car for illumination, would amount to 14,759 pounds per day or 2,418 tons per year.

It is impossible in subway operation to prevent some dust from accumulating on the lamps and reflectors. Reflectors will become soiled or grimy from frequent dusting. These conditions, together with the aging of the lamps and the absorption of light by the clothes of passengers, will materially reduce the available illumination. Where tests are conducted with practically new lamps, clean reflectors and freshly painted ceilings, with no passengers in the car, an illumination at least 25 per cent. higher than the actual amount desired in operation should be provided.

The development of the illumination of the two types of rapid transit cars in New York City, as described in the foregoing, brings out in a very striking manner the value of the effect of the different roof constructions. With practically the same wattage per car, we obtain about the same average illumination in the Municipal car as in the Interborough, although the floor area of the Municipal car is 30 per cent. greater than that of the Interborough car.

The studies made by the New York Municipal and the Interborough Company in working out the methods of illumination for their respective cars, together with the observations which have been made under the various operating conditions, lead to certain conclusions, which may be summed up in the following:

(1) Under favorable conditions, a satisfactory illumination may be obtained in a rapid transit car with about 1.4 watts per square foot of floor area.

(2) That the design of the car roof and the type of illumination may well be considered together, although it will not necessarily follow that the roof design can be subordinated entirely to the illumination.

(3) That about twenty units are necessary for proper distribution of light in cars within the dimensions of the two cars under discussion.

(4) That the location of the lighting units along the center line of the ceiling will not provide a satisfactory illumination under certain operating conditions that occur frequently.

Operating experience has emphasized the necessity of selecting a reflector of sufficiently rugged construction to withstand the shocks to which it will be subjected and yet of a character which will transmit sufficient light to adequately illuminate the upper part of the car, particularly the advertising signs and further, to have as few projections as possible that will collect dust.

The marked reduction in efficiency, caused by even a slight collection of dust on the lamp which cannot be readily dusted by hand without removing same, suggests the desirability of providing car cleaners with a means for cleaning the lamps and shades more efficient than is now in use, as the success of any system utilizing reflected light under conditions in subways will depend to some extent upon keeping both lamps and shades reasonably clean.

We are indebted to Mr. J. S. Doyle, Superintendent of Car Equipment, Interborough Rapid Transit Company, and Mr. W. G. Gove, Engineer of Car Equipment, New York Municipal Railway Corporation, for a number of the photographs and diagrams presented with this paper.

DISCUSSION.

E. E. DORTING (Interborough Rapid Transit Co.): I note the authors state on page 25, paragraph 3, that the momentary variations in substation voltage, due to these wide fluctuations in load, added to the drop in the feeders and return circuits, often result in a voltage at the operating car as low as 450.

In the curve on page 27, which describes the variation in voltage at half-minute intervals, and which I presume at 100 per cent. means the average line volts of 585, I notice the lowest reading given is 90 per cent. and 90 per cent. of 585 would be 527 volts. I have very recently investigated the voltage changes on the Interborough subway cars under operating conditions during the rush hour and find by using a continuous recording volt-meter over the entire trip of a ten (10) car train that only in very few instances does the voltage go below 500, and then only at the extreme end of substations.

On page 28, last paragraph, regarding the car lighting of the New York Municipal Railways Corporation adopting a lighting unit consisting of a 56-watt half-frosted lamp set in a 6-inch Sudan glass reflector, which will be seen in Fig. 7—if I understand rightly the 56-watt lamp is mounted in an S-21 bulb. The 6-inch reflector is designed for a light center given by a S-19 bulb. That means with the 56-watt lamp equipped as now, we will get more of a distributed light due to the low mounting of the lamp and the glass reflector only becomes effective on approximately half of the lamp candlepower. The ceiling must therefore reflect the remainder.

I think Mr. Wilder and Mr. Allen should have incorporated some sketches showing the angle of cut-off. Back in 1915 when the Interborough originally started tests on car lighting, we naturally mounted the first 40-watt lamps in the true position as regards to the reflector, which was a 6-inch type. After running one or two tests we happened to sit directly opposite these reflectors and noticed that the eyes caught the direct glare from the incandescent lamp filament. A suggestion was made to use bowl frosted lamps, but considering the amount of dirt that would collect on the frosting, this idea was abandoned. The result was that we had a concern submit sample holders arranged

with an adjustment on the socket whereby we could raise the lamp eleven sixteenths (11/16) of an inch in the reflector.

The further tests naturally showed a more concentrated light. We increased the foot candles on the seats approximately eight or nine per cent., as well as giving a soft illumination with no direct glare at all. This is purely an added advantage for good car lighting.

Mr. Wilder mentions as follows on page 34, next to the last paragraph:

"Where tests are conducted with practically new lamps, clean reflectors and freshly painted ceilings, with no passengers in the car, an illumination at least 25 per cent. higher than the actual amount desired in operation should be provided."

I believe that at the time this paper was written, we may still have been at war and there was considerable shortage of labor. Mr. Wilder refers in other parts of the paper regarding inefficiency in keeping lamps and reflectors clean. I believe to-day with the help that is gradually coming back and with this factor being taken care of in our car cleaning, that 15 per cent. increased illumination would be sufficient.

H. A. Currie (The New York Central): Although hardly classed as urban the New York Central Multiple Unit car service presents many of the same problems as those described in the paper of the evening.

The most noticeable difference in the characteristics of the cars is the height of ceiling and per cent. of standing passengers. The New York Central Railroad cars have a higher ceiling and there are fewer standing passengers than are encountered in the city service.

A further difference is the requirements on the railroad cars for an auxiliary lighting system when the cars are operating outside the third rail zone. For this auxiliary system ceiling lights connected in multiple and operated from a storage battery charged from third rail were adopted. This illumination was not designed to be as bright as the standard electric lighting but to give practically the same light as was previously furnished for the standard steam coaches.

When the first Multiple Unit cars were designed in 1905 the lighting consisted of 50 16-candlepower carbon filament lamps without shades; 42 of these lamps were located in the car body, 12 of which were located in double brackets on center deck. This gave a value of 6.7 watts per sq. ft. of floor area.

After the introduction of the tungsten filament, these carbon filament lamps were replaced. This change produced a very intense and brilliant light which was a marked contrast to the dark green finish of the car. The first step in the reduction of the brilliancy was the elimination of the center deck lamps. This reduced the light approximately 30 per cent. On a lot of cars delivered in 1913 a further decrease in the number of lighting units in the cars was made. Although the cars were somewhat larger than the original ones the number of lights was cut from 42 to 20. These units were placed 8 on each side of car, one on each bulkhead and one in each saloon. Twenty-three watt Mazda lamps were used with a Doric reflector. The finish of car added materially to the illumination. The center deck being finished in a pearl grey enamel and the remainder of car being finished in light mohogany.

The general result was very pleasing to the eye. The operation of these cars in the same train with the older type of car which contained the exposed light was often the cause of complaint on account of the impression received in stepping from a car equipped with the shaded light to a car equipped with the exposed light. Although from photometric readings there were more foot candles delivered to the reading plane in the later car, the effect on the eye gave a contrary impression.

Since that time the lighting in all the cars has been remodeled. All the center fixtures and one-half the side deck fixtures were removed, and the car repainted and shades furnished.

After further tests and observations it was decided to change the 23-watt lamps and substitute 36-watt lamps. The result of photometric test on two types of lamps showed an average foot candle value of 2.27 for cars equipped with 23-watt and 3.19 for cars equipped with 36-watt lamps. The 36-watt lighted cars give a value of 1.4 watts per sq. ft. of floor space.

The choice of a suitable shade is an important matter. It

should be kept in mind that a shade which has ridges or depressions in which dust can collect and with rough surfaces which may become soiled by handling, should be avoided.

The condition referred to in the paper of the evening and which is illustrated very forcibly in Fig. 2, namely, Candle Power Variation Due to Fluctuating Voltage, is one to which we have given considerable study but as yet have not arrived at any satisfactory solution. In this connection there is a great need of a simple effective regulator which will automatically take up the fluctuations in voltage.

G. H. STICKNEY: On first sight, the lighting of car interiors would seem to be an easy problem. This paper, however, indicates some of the difficulties, a few of which are peculiar to this type of service. Among the conditions encountered may be mentioned the necessarily low hanging height, the mechanical vibration, the high circuit voltage, (necessitating the series arrangement) and excessive voltage variation. However, since the installation is duplicated throughout the many cars of a system, it is well worth while to make an extensive study in determining how to secure the best practical effect in a typical car. As regards various features of the lighting, there will be different demands in different classes of service. A subway car is likely to require something different from a surface car. The interurban car differs in its requirements from the city car, and even the dimensions, finish and seating arrangements of the car, all have a bearing on the problem.

As soon as it seemed probable that the tungsten filament lamp had become rugged enough for this severe service, we took up the question, and Mr. Porter and I ran some rather extensive investigations on the cars of the Bay State Street Railway Company, and later on other roads.

In applying shades to conserve the light and introduce diffusion, we immediately ran into the question of protecting passengers from the dropping or breaking of shades, so that it became necessary to secure the development of holders more substantial than those used in ordinary interior lighting.

The matter of economy also became an important factor in interesting railway companies. Owing to the low rate at which

they figure the cost of power, current economy was not considered very important.

Further complication in this connection was that in the accounting of some of the street railway companies the use of reflectors involved an extra expenditure on the part of the Equipment Department. While this meant an over-all economy, through the saving of current, particularly on the peak load, equipment men were reluctant to increase their expenses, since that department was not credited with the saving.

We have been inclined to advocate a single line of units down the center of the car rather than the double row. This puts the light source higher and further out of the range of vision, and in the cross-seat cars there is less of a shadow effect than with the double row.

In our earliest investigations, the railway men warned us with regard to the shadows from people standing, and rather extensive investigations were run. The central lighting system was found satisfactory in light-finished cars, both with the cross-seat and side-seat system.

In the case of the Brooklyn cars, the seating arrangement is particularly unfavorable because when the car is crowded, the passengers stand on two and even three sides of seated passengers, and it is evident that under this condition that with the dark finish on the side-wall, the central lighting might easily become unsatisfactory. Both the Brooklyn and the Interborough subway cars are above ground throughout a part of their run, and this makes a demand for a higher intensity on account of adaption of the eye from daylight on entering the subway. In fact, any subway car will in daytime need more light than a car which is not lighted until after dark.

Referring to some details in the paper, I notice the authors mention 40-watt lamps. The standard street railway lamp corresponding to the 40-watt multiple MAZDA is 36-watt. I would like to ask them to advise which one is used.

In regard to Mr. Dorting's comment as to the allowance of 25 per cent. for depreciation, I think I would be inclined to adhere to that figure, even under the best maintenance conditions, partly on account of the voltage variation and partly on ac-

count of the rapid rate at which dirt is bound to accumulate in cars. I would like to commend the excellent maintenance referred to by Mr. Dorting as quite important, both on account of the economy of light and the appearance of the installation. We are indebted to the authors for this exact information derived from their thorough investigation of subway lighting. It is important, both as a guide and example. In interpreting this data, however, we must not overlook the fact that different conditions will make different requirements.

NORMAN MACBETH: I am inclined to feel that the traction authorities Mr. Stickney mentioned who gave very little attention to the economy of re-arrangements of lamps were perhaps right. Less attention should be given to reduced wattage and more to lighting satisfaction. I remember coming across the point a couple of years ago in some of this car work that the average motorman may use a great deal more energy in the careless use of his controller than is required in the lighting of the train.

I have had a daily experience for some years with subway trains and also commuting on the N. Y. & N. H. and practically commuting on the Pennsylvania. Reading in these cars is not always satisfactory. The necessary shifting—even in the New Haven where there isn't aisle crowding—is necessary to keep shadows off your paper and to get the best light—which ofttimes gives you an undesirable reading position.

I agree on the factor given by Mr. Wilder of 25 per cent., and I believe it ought to be larger. Illumination measurements in an empty car may show results that would lead to a conclusion that a lighting arrangement was satisfactory which in an occupied or crowded car might be far from it.

On looking over the paper it appears that all these measurements were horizontal plane measurements. I believe that you could well afford to take what you would call a group illumination measurement on the reading plane. That is, have the operator sit in the seat where the reader would be seated, with his photometer placed to measure the illumination in the plane in which a passenger would observe his reading page, then group three or four people around in front of him. You wouldn't need

a crowded car, three or four shadow makers would probably be as satisfactory.

On the question of advertising car cards, the authors could well have brought in brightness measurements, and I believe that in rearranging any car lighting system that the advertising interests ought to be sold on a new car lighting system. They ought to be given their usual car card arrangement with bare lamps and then the proposed arrangement with lamps with reflectors and make a few simple acuity tests on the ability to read those car cards seeing past bare lamps and lamps with reflectors.

If you will consider what those car cards cost the advertiser you will probably find that the reading light for the passenger is an inexpensive by-product.

I believe we would have gotten farther in the same time if the start had been made from the carbon filament basis of 2 or 3 watts per square foot to undertake to light those cars better —rather than considering the old intensities as more or less of a standard and trying to see how much energy could be saved.

ARTHUR MILLER: When we first studied the illumination requirements for the cars of the Interborough Rapid Transit, the all-important factor seemed to be to obtain the proper intensity on the plane of illumination, and after tests the type of glassware to which the authors referred as "Sudan" was chosen as accomplishing the best results. I might mention that this particular glassware is very dense, giving high reflection and low transmission. When the objection came through from the advertising people on account of the low transmission giving insufficient intensity on the signs, we made some new tests and found that by using a lighter density glass we obtained nearly the same intensity on the plane of illumination and a higher transmitted light which would provide ample intensity on the signs themselves.

The reflector which I believe has recently been approved, is of a light density opalescent pressed glass which gives approximately the same results both as to transmitted and reflected light, as a heavy density glass blown thin, similar to the type now used by the New York Municipal.

Mr. Macbeth stated that possibly we could obtain an asymmetrical distribution by having the glass lighter on one side than on the other. Undoubtedly this could be accomplished, but I am afraid in order to do so, the cost of manufacture would go up so high that the price the railroads would be forced to pay for the reflector would be prohibitive and therefore impracticable.

J. L. MADISON: I wish to compliment the authors upon their paper on the car lighting, and I just want to say a word about the question of the efficiency of the construction of the roof of the car. I want to ask a question, rather. I wonder if it is not possible that the height of the roof has something to do with the efficiency and also the point that you put the lights up in the ceiling in the upper deck and thereby spread the light out further. Now possibly we could break the poor construction or the poor reflecting quality of the flat roof with upright sides by a reflector in the roof in the ceiling. We know that reflectors mostly when they are dense don't throw out any lights to the sides and only reflect downwards, and in that way we could obtain sufficient lighting or better lighting than by the monitor-shaped roof.

L. C. PORTER: A relatively high intensity, such as $4\frac{1}{2}$ foot-candles, becomes necessary at least during the daytime, when the eyes observe the greatest contrast between artificial light and that of the sun.

The matter of voltage regulation has been developed by the perfection of a car lighting motor generator set, which allows a variation of 400 to 600 volts on the motor with only one-half volt variation on the generator side. Since the generator delivers 32 volts, the necessity for using five lamps in series is eliminated, allowing the use of higher efficiency gas-filled lamps. For interurban service, the set enables the use of a constant headlight.

Proper reflectors should help alleviate the glare received by standing passengers. A seated person is more liable than the former to receive the direct rays of the lamp.

White ceilings not only increase the effective illumination, but decrease glare, glare being relative, depending upon the contrast between the intensity of the light source and its background.

Clifton W. Wilder: The authors have very little information on the subject of the angle of the cut-off of shades for car use. Further study along the lines of developing a more efficient shade for use in the illumination of rapid transit cars is very desirable.

Twenty-five per cent. increase in the illumination, with new interior painting, shades and lamps, over what is desired under regular operating conditions, which seems to have drawn out somewhat difference of opinion, is of course an estimate. It has been found very difficult to arrange the lighting units so as to eliminate all shadows. With the latest arrangement of lights in the Interborough car, it is very easy for a standing passenger with an open newspaper to cut off the light of a seated passenger directly underneath the paper and, in the Municipal car, where the seats are so located as to permit passengers to stand on three sides, shadows are not only cast by newspapers but by the standing passengers themselves. In order to lessen so far as possible the annoyance to readers cast by shadows, a liberal increase in illumination under the conditions described above is very desirable.

The illumination, as indicated by the various curves in this paper, was determined from observations of the illumination on horizontal planes.

The height of the roof referred to by Mr. Madison is undoubtedly an important factor in obtaining a satisfactory distribution of light. The roof of the Municipal car is very nearly a turtle back roof, providing an almost uniformly curving reflector from one side of the car to the other, reflecting the light rays down where needed in a very efficient manner. This form of roof also enables the lighting units to be installed at a greater height from the floor than the monitor roof of the Interborough car, which materially adds to the uniform distribution of the light.

ILLUMINATION NOTES *

Hotel Rooms.

BY W. F. LITTLE AND A. C. DICK

A survey of the light intensities in hotel rooms was made for the War Service Committee and by their consent it has been released. Through the co-operation of the Illumination Department of the New York Edison Company, access was gained to twelve hotels and by courtesy of Mr. L. B. Marks data for another hotel were secured.

The investigation was carried on in the following hotels:

Astor	Imperial
Algonquin	Seville
Biltmore	Latham
Marie Antoinette	Normandie
Seymour	Union Square
Marlborough	Gerard
Breslin	

With a few exceptions the investigations were carried on in typical rooms. In most cases measurements were made in rooms of average size.

Table I shows the room dimensions, watts, watts per square foot and illumination intensities in the rooms investigated. Table II shows the lamps, fixtures, glassware and notes on room furnishings.

The data obtained are shown in the following tables:

It may be interesting to compare the values found with the average consumption rates for the low wartime level suggested by the War Service Committee. The suggested value for semi-public places was 0.6 watt per square foot. Of the 41 rooms investigated, 21 were found to be lower than this minimum and 8 were found to be 0.6 watt per square foot. Also, the average

* Paper presented before the New York Section of the Illuminating Engineering Society, New York, N. Y., January 9, 1919.

TABLE I.

Room				Watts	Watts per sq. ft.	Horizontal foot-candles					
Hotel	Number	Dim. feet	Area sq. ft.			Under center fixture	Approx. avg.	Bureau	Chiffonier	Dressing table	Desk
A	290	16 x 19	304	190	0.6	—	1.5	4.5*–1.0**	—	4.5*	3.5 dl
	286	15 x 18	270	145	0.5	—	0.6	4.5*	—	—	2.0
	294	15 x 18	270	220	0.8	3.5	1.5	3.5*–2.0**	—	—	2.5 dl
B	206 (parlor)	20 x 20	400	150	0.4	9.0	1.5	—	—	—	1.5
	206	12 x 15	180	75	0.4	8.0	2.0	6.0†	2.0	—	—
	201	10 x 14	140	75	0.5	5.0	1.5	10.0†	—	—	2.0–0.7**
	200	14 x 15	210	75	0.4	9.0	—	—	12.0†	—	1.5
	720	18 x 22	396	195	0.5	6.0	3.0	—	4.0*	9.0*	10.0 dl
	718	18 x 20	360	200	0.5	10.0	2.0	—	—	—	10.0 dl
D	76 (parlor)	11 x 14	154	150	1.0	4.0	—	—	—	—	5 drop
		10 x 12	120	75	0.6	5.0	1.8	—	—	—	—
		10 x 14	140	75	0.5	—	0.9	0.7–0.5**	—	—	—
	33	13 x 17	221								
	(parlor)			125	0.6	7.0	—	3.5	—	—	1.2
		8 x 13	104	75	0.7	3.0	—	—	—	—	—
E	216	10 x 20	200	75	0.4	—	0.4	0.5	—	1.0–0.5**	2.5
	263	14 x 10	140	75	0.5	4.5	1.0	1.0	—	—	0.6
F	118	20 x 12	240	150	0.6	4.5	0.5	2.5	0.5	—	1.5
	116	20 x 12	240	150	0.6	2.5	0.5	3.5	1.0	—	0.5
G	115	19 x 20	380	225	0.6	5.0	—	3.5*	—	—	—

* Pair of bracket lamps burning. ** In shadow of person sitting or standing in front of desk, bureau, etc.
† One bracket lamp burning. dl desk lamp. All rooms are bedrooms excepting where otherwise noted.
(*a*) All lights. (*b*) Ceiling lights only.

TABLE I.—(*Continued*)

Room				Watts	Watts per sq. ft.	Horizontal foot-candles					
Hotel	Number	Dim. feet	Area sq. ft.			Under center fixture	Approx. avg.	Bureau	Chiffonier	Dressing table	Desk
H	207	12 X 15	150	100	0.6	8.0	2.0	2.0–1.0**	1.5–1.0**	—	—
	206	12 X 20	240	125	0.5	15.0	—	—	2.0	—	1.0–[illegible]**
	205	14 X 21	294	75	0.3	8.0	—	2.5–1.5**	—	—	1.0–[illegible]**
	222	15 X 21	315	100	0.3	6.0	—	1.5–0.7**	1.5	—	[illegible]
I	1121	9 X 11	99	120	1.2	10.0	—	2.0	—	—	1.0–[illegible]**
	1120	9 X 12	108	120	1.1	9.0	2.5	—	2.0–1.0**	—	—
	1109	10 X 12	120	120	1.0	8.0	2.5	3.5–1.5**	—	—	[illegible]**
	1104	12 X 18	216	160	0.7	11.0	3.0	3.5–2.0**	2.0–1.5**	—	[illegible]**
	1103	12 X 17	204	160	0.8	10.0	2.5	3.5–2.0**	2.5	—	[illegible]**
J	218	15 X 10	150	50	0.3	3.5	0.6	0.7	—	—	—
	216	14 X 16	224	50	0.2	—	0.7	0.8	0.4–[illegible]**	—	—
K	41	12 X 14	168	50	0.3	5.0	—	1.0–[illegible]**	—	—	—
	40	12 X 14	168	85	0.5	8.0	—	—	2.0–[illegible]**	—	[illegible]**
L	87	12 X 12	144	60	0.4	2.5	—	3.5	—	—	—
	86	10 X 8	80	100	1.25	9.0	—	10.0	—	—	—
	8th floor Apt. B parlor										
		20 X 20	400	[illegible]	[illegible]	7.0	[illegible]	—	—	—	[illegible]
		14 X 14	196	75	0.4	7.0	—	[illegible]–1.0**	—	—	—
M	(parlor) Dining room	—	[illegible]	200	[illegible]	3.35	—	—	—	—	[illegible]
		—	[illegible]	75	[illegible]	[illegible]	[illegible]	—	—	—	—
		—	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—	—
		—	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—	—
		—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—

* Pair of bracket lamps burning. ** In shadow of person sitting or standing in front of desk, bureau, etc.
† One bracket lamp burning. ‡ desk lamp. All rooms are bedrooms excepting where otherwise noted.
(a) All lights. (b) Ceiling lights only.

TABLE II.

Hotel	Room		Lamps		Fixtures		Glassware, etc.		Notes
	No.	Type	No.	Watts	No.	Location	Description	Type	
A	290	Bedroom	6	15	5	Wall	Direct	Prismatic	White ceiling, light trim, medium walls, dark furnishings.
					1	Desk		Silk	
			1	100	1	Center	Semi-indirect	Diffusing	
	286	Bedroom	3	15	2	Wall	Direct	Prismatic	White ceiling, light trim, medium walls, dark furnishings.
					1	Desk		Silk	
			1	100	1	Center	Direct	Prismatic	
	294	Bedroom	8	15	7	Wall	Direct	Prismatic	White ceiling, walls and trim, dark furnishings.
					1	Desk		Silk	
			1	100	1	Center	Semi-indirect	Diffusing	
B	206	Parlor	6	25	3	Center	Direct	Clear & frosted	White ceiling, light tan walls, dark furnishings.
					2	Wall	Direct	Clear & frosted	
					1	Table	Direct	Clear & frosted	
	206	Bedroom	3	25	2	Center	Direct	Clear & frosted	White ceiling, light tan walls, dark furnishings.
					1	Wall	Direct	Clear & frosted	
	201	Bedroom	3	25	2	Center	Direct	Clear & frosted	White ceiling, light tan walls, dark furnishings.
					1	Wall	Direct	Clear & frosted	
	200	Bedroom	3	25	2	Center	Direct	Clear & frosted	White ceiling, medium walls, dark furnishings.
					1	Wall	Direct	Clear & frosted	
C	720	Bedroom	6	15	6	Wall		Silk	White ceiling, walls and trim, dark furnishings.
			3	15	2	Wall		Silk	
					1	Desk		Silver	
			1	60	1	Center	Semi-indirect	Diffusing	
	718	Bedroom	2	25	2	Table		Silk	White ceiling, walls and trim, dark furnishings.
			5	15	1	Desk		Silk	
					4	Wall		Silk	
			1	75	1	Center	Semi-indirect	Diffusing	

TABLE II.—(*Continued*)

Hotel	Room No.	Room Type	Lamps No.	Lamps Watts	Fixtures No.	Fixtures Location	Glassware, etc. Description	Glassware, etc. Type	Notes
D	[illegible]	Parlor	6?	25	5 1	Center Drop	Direct Direct	Frosted Frosted	
		Bedroom	3	25	2 1	Center Drop	Direct Direct	Frosted Frosted	
		Bedroom	3	25	2 1	Center Drop	Direct Direct	Frosted Frosted	
	33?	Parlor	5	25	5 1	Center Drop	Direct Direct	Frosted Frosted	
		Bedroom	3	25	3	Center	Direct	Frosted	
E	216	Bedroom	3	25	3	Center	Direct	Frosted	White ceiling, light brown paper, dark brown trim
	[illegible]	Bedroom	3	25	3	Center	Direct	Frosted	White ceiling, light grey paper, dark furnishings
F	118	Bedroom	6	25	4 2	Center Drop	Direct Direct	Frosted Frosted	White ceiling, light grey paper, dark furnishings
	[illegible]	Bedroom	6	25	4 2	Center Drop	Direct Direct	Frosted Frosted	White ceiling, light grey paper, dark furnishings
G	[illegible]	Bedroom	[illegible]	25	6 2 1	Center Wall Table	Direct Direct Direct	Frosted Frosted Frosted	White ceiling, medium green walls, dark furnishings
H	[illegible]	Bedroom	4	25	3 1	Center Wall	Direct Direct	Clear & frosted Clear & frosted	White ceiling, medium walls
	[illegible]	Bedroom	[illegible]	25	[illegible] 1 1	Center Wall Table	Direct Direct Direct	Clear & frosted Clear & frosted Clear & frosted	White ceiling, brown walls, brown trim, dark furnishings
	[illegible]	Bedroom	[illegible]	25	3	Center	Direct	Clear & frosted	White ceiling, light tan walls
	[illegible]	Bedroom	4	25	4	Center	Direct	Clear & frosted	White ceiling, light tan walls

TABLE II.—(*Continued*)

Hotel	Room		Lamps		Fixtures		Glassware, etc.		Notes
	No.	Type	No.	Watts	No.	Location	Description	Type	
I	1121	Bedroom	3	40	3	Center	Direct	Prismatic	White ceiling, light walls.
	1120	Bedroom	3	40	3	Center	Direct	Prismatic	White ceiling, medium walls.
	1109	Bedroom	3	40	3	Center	Direct	Prismatic	White ceiling, medium walls.
	04	Bedroom	4	40	4	Center	Direct	Prismatic	White ceiling, white walls.
	1103	Bedroom	4	40	4	Center	Direct	Prismatic	White ceiling, medium walls.
J	218	Bedroom	2	25	2	Center	None	—	White ceiling, brown walls.
	216	Bedroom	2	25	2	Center	None	—	White ceiling, brown walls.
K	41	Bedroom	2	25	2	Center	Direct	Clear	White ceiling, medium walls.
	40	Bedroom	1	25	2	Center	Direct	Clear	White ceiling, medium walls, dark furnishings.
			1	60					
L	87	Bedroom	1	60	1	Center	Direct	Clear	White ceiling, light walls.
	86	Bedroom	1	100	1	Center	None	—	White ceiling, light walls.
		Parlor	5	25	5	Center	Direct	Clear	White ceiling, pale blue walls.
		Bedroom	3	25	3	Center	Direct	Clear	White ceiling, pale blue walls.
M		Parlor	8	25		Center Wall Desk	Enclos'g globe Direct	Diffusing Diffusing	
		Din'g room	3	25	3	Center	Semi-indirect	Diffusing	
		Bedroom	6	25	3 3	Center Wall	Enclos'g globe Direct	Diffusing Diffusing	
		Bedroom	7	25	3 3 1	Center Wall Desk	Enclos'g globe Direct Direct	Diffusing Diffusing Diffusing	
		Bedroom	5	25	5	Wall	Direct	Diffusing	

foot-candle intensity is not only below that required for comfortable reading, but in most cases only central ceiling fixtures are used. Invariably the writing desk or table is at the side of the room, and if no desk lamp is provided the guest must write in his own shadow.

Much lower average illumination than that required for comfort in reading and writing may produce a very satisfactorily lighted room, provided the fixtures are advantageously located. It is essential, however, that the bureau, dresser and chiffonier, and usually essential that the desk or writing table be placed along the wall. With this arrangement of furniture, and no wall brackets, or desk lamps, the guest is obliged to work in darkness.

Table III presents some of the salient features of the investigation.

TABLE III.

Data available in 41 rooms	
Watts per sq. ft.	Per cent. of rooms
0.2 and 0.3	17
0.4 and 0.5	34
0.6 and 0.7	30
0.8 and 0.9	7
1.0 and over*	12

Data available in [illegible] rooms	
Lamp wattage	Per cent. of lamps
15	23
25	61
40	11
60	2
75	1
100	2

No. of outlets or fixtures	Per cent. of rooms
1	44
2	22
3	15
4	8
5	2
6	2
7	0
8	0
9	5
10	2

Type of glassware	Per cent. of rooms
Frosted	53
Opalescent	8
Prismatic	22
Clear	11
None	8

17 per cent. of rooms were equipped with desk lamps.

55 per cent. of rooms were equipped with wall switches.

98 per cent. of rooms were equipped with center fixtures.

19 per cent. of the lamps were frosted.

*Maximum: [illegible] watts per sq. ft. in room approximately [illegible] feet with pendant cord and bare 100 watt gas filled lamp supplied by guest.

DISCUSSION.

G. H. Stickney: This paper is a statement of conditions found. As such it is a valuable contribution but not readily subject to discussion, except to interpret it as an indication of whether or not the practice represented is adequate. From a hasty inspection, it appears to conform to my own rather extended personal experience. In general the lighting in guest rooms is not suitable for the requirements of a business man, who may have written work to do and seeks the privacy of his room to avoid interruption. While a high intensity of light throughout such a room is not necessary, it certainly is highly desirable to have good illumination at a few points, such as the writing table and dresser. Such illumination should come from certain directions in order to meet the requirements and avoid objectionable shadows. With notable exceptions, this need is not met even in first class hotels. In the bathroom a central lighting fixture is quite common. Especially in a large bathroom, this arrangement does not produce a light suitable for shaving. It is more important to have bracket lamps near the mirror, in which case the central fixture could ordinarily be dispensed with.

Presumably, one of the important problems in hotel lighting is the waste of light in guest rooms, due to the occupant going away and leaving the lights on. Some hotels are using a door switch, which turns out the lights when the door is locked from the outside. I believe the saving derived from the use of such an arrangement would far exceed the cost of providing adequate illumination for the room during its few hours of use. Such an arrangement also has considerable of an advertising value in that it is much more cheerful on entering the room to find it lighted without the necessity of hunting around for the switch.

There certainly is considerable room for improvement, even among the best hotels, in this connection.

F. J. McGuire: Hotel illumination impresses me as a problem that, in many respects, is similar to that of the illumination of the home, especially when one ponders on the many features that have to be considered such as the parlor, reading and writing room, billiard room, bedroom, lobby, etc.

A large percentage of our population throughout the country

know none other than hotel as their home, while even a greater percentage, who by force of their means of livelihood spend the greater part of each year in hotels, must endeavor to find as much home comfort as possible in same.

Since such appears to be the case it would seem but reasonable that these structures should afford as much of the comforts of home as is practicable. To accomplish such an end requires, however, that that feature of the subject with which we have to deal, namely, artificial illumination, should be dealt with in such a manner as will insure all due observance of what has always appealed to me as the fundamental principles upon which true illumination should be based, viz: efficiency, economy and artistic harmony.

Let us for a moment consider some of those features heretofore referred to—therefor one is the parlor. Here I believe you will agree with me the lighting specialist is afforded the best opportunity to display his knowledge of what is truly efficient, economical and artistic, and the methods necessary to adopt for the conservation of vision.

Then, again, we have the retiring or bedroom. Many people, desiring as it were to avoid the general public, utilize those sections of the premises for purposes of reading and writing as they afford a better opportunity for mental concentration, as in the case of Mr. Stickney, who realized the futility of attempting to formulate a long technical report in the general reading and writing room.

Under such circumstances, while this room in a general sense may resemble your home bedroom, it should not be treated, except in one respect, viz: the furnishing of a center ceiling medium of light distributing unit.

Yet there are hotel proprietors who never seem to have given this the slightest thought. Some, however, have gone a step beyond furnishing a center ceiling light by adding one or two bracket lights at the dresser whereas by a very slight effort and additional cost an inexpensive, properly shaded, table lamp could be furnished these rooms to the great comfort of the guests. I understand that some of our enterprising hotel proprietors within very recent date are adopting this latter improvement.

As I speak I have in mind the problem that the City Government now has before it in the lighting of a Nurses' Home. In addition to a proper diffusing center ceiling lighting unit, which by the way, is operated by means of a switch immediately at the right of the entrance door, a bracket has been installed with a bowl type reflector and a pull chain socket over the mirror of the dresser. From the canopy projects a socket into which can be inserted the flexible cord for a table lamp. Thus two one-light fixtures are operated from one outlet.

Then comes the problem of illuminating the hotel dining room. In some of the dining rooms to be seen throughout the country the system of lighting is at present little short of torture. The conservation of vision was evidently never for a moment considered by those having to deal with this problem. The fact that the presence of the white table cloths, napkins, etc., was furnishing an intense co-efficient of reflection seemed to have been lost sight of, and a form of direct lighting has been installed producing effects not only extremely irritating but equally injurious to the eyesight of the diners.

On the other hand, had semi-indirect bowls of a dense glass with properly shaded table lamps been installed, a most beautiful blend of light, shade and color would be the result, making the place far more attractive and comfortable.

This subject, it appears to me, should receive a most earnest and general consideration on our part as a Society for the reason that the proper illumination of our hotels, palatial residences and even the humblest of our people's homes, is a duty we owe to ourselves and the public as it not only has a physiological, but, I believe, an almost equal psychological effect. This, however, I am convinced, will require on the part of the illuminating specialist a knowledge of the primary principles, at least, of architecture, decorative art, and the conservation of vision.

PERCY W. COBB: I am always at a loss when called upon to discuss a paper on an engineering subject. The work I have been engaged in has reference more to the functions of vision. What I shall have to say, therefore, applies rather to vision as it relates itself to light conditions than to the performance of any given lighting system as usually measured. The contrast

has to be drawn between two separate problems: the placing of lamps, glassware, etc., and the resulting illumination at various points and upon various planes on the one hand, and upon the other the effect that the resulting light distribution will have directly upon the eye itself.

The two eyes, taken together, have a certain "field of vision." With the head in the center of a large hollow sphere, for illustration, the area of the spherical surface that can be seen at any instant is of perfectly definite extent. It will be found that the combined field for the two eyes extends horizontally about 100° to the right and left of, 50° above and 70° below the line of direct vision. At any instant the eyes are, therefore, subject to all the light that comes to them from the area indicated by these angles. If the sphere were transparent we might plot upon its surface at various points, the degree of stimulation that the corresponding points of the retinae receive. To do so, we should have to use as ordinates—corresponding to altitudes in a relief map—the photometric brightnesses of the various elements of the visual field, and in such a map we would have a pattern showing exactly how the retinae are being stimulated.

It would seem only logical, therefore, that in the study of any system or particular case in illumination practice it would be not only relevant but essential to study the brightness of the visual field from the point at which the user is placed—remembering that the angles just mentioned include only the visual field at any instant; that the eyes are continually changing their direction; and that consequently, in practice, the eyes are subject to areas of brightness much beyond these angular limits.

It would be a long and tedious matter, no doubt, to prepare an accurate brightness-map of even a part of the visual field in this way. Such, however, is not necessary, at least for a beginning, but certain cardinal points and areas in the field could be advantageously studied. We might enumerate in this connection: (1) the light sources or units themselves, (2) all highly illuminated areas and (3) all other areas of considerable extent and tolerable uniformity of whatever brightness. The total illumination at the eyes measured on a plane at right angles to the line of sight would also be of interest.

Naturally, objects presented in an illuminated space, such as a railway car, may not only diminish the amount of light incident upon any plane—owing in this case to the absorption of light by the dark clothing of the passengers, to say nothing of the shadows directly cast—but such objects will directly modify the brightnesses in the visual field in a much more extensive and radical way. Surface brightness is a function not only of incident illumination; it is a very direct function of the surface illuminated as well.

It is true, the argument cannot well be carried, by the physiological route, from brightness distribution in the visual field to probable visual comfort and efficiency. Too many steps in the physiology of vision, as related to light distribution, are still wanting. It is nevertheless to be expected that comfort and efficiency, estimated as in present common practice, will be found on investigation to be much more closely related to brightness distribution than to illumination distribution. Technical research upon this point would be very welcome.

A. S. Alexander: In reference to hotel lighting just made by Messrs. Little and Dick, I wish to point out what is being done at the present time to improve hotel lighting in some respect.

A gentleman just referred to the poor lighting of some hotel dining rooms, where the glare of the white table cloth is very annoying. As an example of what has been done with this problem, to eliminate the objectionable fixture, I wish to explain what was done at the Hotel Statler, in St. Louis.

In several of the public rooms where candle chandeliers were used, a silk shade was placed over each bulb, with a glass reflector within, throwing the light toward the ceiling, making each light a semi-indirect unit, and at the same time preserving the effect of a decorative chandelier to complete the decorations required for the room. This is a great improvement on the old style of using the exposed lamp.

I may also say that in the later hotels there has been an evolution as to certain fixtures of the hotel guest rooms. Recently a new type of lighting fixture has been produced, consisting of an indirect metal bowl, with an opening in the bottom, where a glass disc diffuses the downward light and also illuminates the out-

side of the indirect bowl and consequently eliminates the harsh effect of contrast that an indirect bowl ordinarily produces. This kind of fixture is now used in several of the very latest hotels; for instance, the Hotel Cleveland, in Cleveland, Ohio. It was also installed lately in some of the older hotels, for example, Hotel Ansonia, New York.

This type of fixture is an example of progress in lighting of any kind of rooms.

A gentleman just referred to hotel guests being in their own shadow at the dresser or desk in hotel bedrooms. I have had that experience many times, being compelled to push the table around to the best position under a bare light in the center of the room to take care of business matters when travelling.

A well equipped hotel has now a portable lamp in the guest room, with well shaded bulbs, to have light on the table and not in the eyes. Brackets are placed at either side of the dresser, or else, as in the Pennsylvania Hotel, a metal reflector, directly over the dresser. Fixtures of this type are made adjustable and can be turned so as to have the light where wanted at the dresser.

The hotels investigated, as stated by Messrs. Little and Dick, are quite old and have the older system of lighting and it is, no doubt, difficult and expensive for the proprietors to rewire their establishments to suit more up-to-date lighting, but many improvements are being carried out as they are continually changing for the better and for that reason helping to solve the problem of better lighting, which is so badly needed.

Some hotels are, indeed, very poorly lighted, and for that reason not inviting and it is a great field for co-operation among engineers, fixture manufacturers and others.

The authors have recorded here some excellent information. It appears to me to form an indictment of lighting salesmanship

Without noting the names of prominent and particularly modern hotels in this, the newest large city in the world, we could well believe that this investigation related to ten or twenty years ago.

Mr. Stickney mentioned the door-lock switch—I don't know whether he referred to the Statler in Cleveland or not. This I consider a real economy feature that can be endorsed. It is about the only economy feature that ought to be endorsed in hotel room lighting. The Statler also puts the morning paper under your door. That morning paper costs approximately twice as much as most of the room lighting recorded in this paper—considering four hours a night room lighting and a retail rate for energy. It is remarkable that where you pay $2.50 or $3.00 or $4.00 for the privacy of a room in a hotel designed for the comfort of its guests that the lighting should be as inadequate as here shown, when we consider that this lighting is not expensive but probably costs less than the laundry service for a soiled towel.

The Statler has also arranged effective lighting from fixtures on the furniture, which in my opinion ought to be popular in every home. You constantly desire to shift your furniture, and lighting fixtures from a decorative standpoint belong to your furnishings; they don't belong to the front porch or the end gable—nor should the fact that "George Washington once occupied this room" be given as a reason for lighting belonging to the G. W. period.

I don't know whether the appropriation for the tests was so limited that they could not go further than the brief description of walls and ceilings, but I would like to see Capt. Cobb's suggestion followed out that brightness or contrast measurements be a part of all such tests.

W. F. LITTLE: As stated in the paper, the survey was made for the Committee on War Service, and that Committee was interested only in general illumination values; therefore, no effort was made to secure brightness data or many other values which might add greatly to the value of a paper on hotel lighting.

The Committee asked for a survey of the illumination intensities of the New York hotels, and in the opinion of the authors, the hotels visited represent a fair average, and these data are presented for what they may be worth.

Mr. Alexander states that the hotels selected are old. Their average age is probably much less than the average of all the hotels in New York. Also, some of the older houses have the more modern equipment, as it was noted in several instances that the wiring and fixtures had been re-vamped and changed with the redecorating. In some instances the newest fixtures were the greatest offenders from the standpoint of the several essential fundamentals mentioned by Mr. McGuire.

TRANSACTIONS
OF THE
Illuminating Engineering Society
PART II -- PAPERS

VOL. XIV — MARCH 20, 1919 — NO. 2

THE NEW YORK STATE AUTOMOBILE HEADLIGHT LAW.*

BY FRANCIS M. HUGO, SECRETARY OF STATE

With approximately 465,000 motor vehicles on the 80,000 miles of highway in New York State, there are today two things paramount in creating danger on the road, the one being the careless driver, and the other, the glaring headlight. We have been getting after the careless driver with excellent results for several months. It is of equal importance that we devise some means of eliminating as far as possible the dangers attendant from glaring headlights.

Two years ago New York State passed a law as the first step towards ridding our highways of the dangerous glare and dazzle which was the source of a very high percentage of accidents occurring after darkness. It was impossible, however, to enforce this law, for there was no definite provision as to just what really constituted a glare. The law was so constructed that each constable and each justice of the peace could set his own standard and thus become the final arbiter. The result was a confusing situation and little good came from the law.

Last year, another law was drafted, and became operative during the summer. We have done our best in an endeavor to work out a solution of the problem along practical lines. The provisions of our headlight law are familiar to the most of you. Tests of some fifty-five or sixty light controlling devices were made during the months of July and August, and I am frank in saying that I believe that no State in the Union ever made more scientific tests than New York; that no state has entered into the solution of the problem with greater diligence.

* An abstract of an address presented before the twelfth annual convention of the Society, October [illegible].

The specifications prepared by the Illuminating Engineering Society are efficient and I think reasonable, and should be complied with. There are many people, no doubt, who criticized the State because of what appeared to be unnecessary slowness in getting the headlight law in operation, but these did not understand the thoroughness of the tests that were being made.

At the conclusion of the tests, the authorities throughout the State were notified of the results and supplied with pamphlets giving them a list of lenses and light controlling devices as well as the candlepower permissible with each, and asking their co-operation in order that the law might be enforced and with the enforcement that glare and dazzle might become a thing of the past as far as possible, and that accidents arising from such, be lessened. October 15th, was given as a date by which motorists should properly equip their cars with headlights coming within the requirements of the law. It should be remembered that the office of Secretary of State of New York, is without power or jurisdiction in the enforcement of laws, but it should also be equally as well remembered that this same office is always ready to co-operate with the authorities in securing a betterment of existing motor vehicle conditions.

Up until recently there has been an altogether too common use of bulbs of too high a candlepower on the highways of New York State. In short there has been too much light. We are doing our level best to regulate this light to the end that night driving will be safer. We do not want too much light, neither do we want too little. There is a happy medium, and I am frank in saying that I believe that automobilists in general and the manufacturers of headlights are with us in our task of the present day. There is just as much danger to either automobilists when one machine is equipped with lights of a glaring and dazzling nature as there is to the motorist who creeps along with lights that are not of sufficient candlepower to warn him in time of dangers in his path.

I know that New York State is better today because of the headlight law that was passed a year ago. It is a step in the right direction, a step that is being watched with interest by several of the other states. There is no question but that the law is being

violated in perhaps thousands of cases, but on the other hand there is no question but that tens of thousands of motorists have equipped their cars with lights that are legal, lights that serve the purpose of illuminating the highway at a reasonable distance, and yet ones which are not so intense as to become a factor in accidents.

This year will bring about a more strict observance of our law. It is admittedly a hard proposition for the layman and for the authorities, particularly in smaller communities, to determine the exact tilt and other principles laid down as the result of scientific tests. But of this much I am sure—New York State has taken a step in the right direction; there is less glare and dazzle on our highways than ever before and the records show a decrease in night accidents attributable to the use of too strong headlights.

REPORT OF 1917-18 COMMITTEE ON AUTOMOBILE HEADLIGHTING SPECIFICATIONS.*

RENDERED TO THE COUNCIL.

At the outset the Committee deemed it necessary, in order that progress might be made toward the formulation of automobile headlight specifications, to conduct tests for the purposes of studying the problem and particularly to collect numerical data bearing upon it.

PELHAM PARKWAY TEST.

For the purpose of organizing and conducting these tests, the Committee asked and received the hearty co-operation of the Lighting Division of the Standards Committee of the Society of Automotive Engineers under the leadership of Mr. M. W. Hanks. Accordingly, tests were instituted which were reported upon before a joint meeting of the Metropolitan Section of the Society of Automotive Engineers and the New York Section of the Illuminating Engineering Society, New York, April 11, 1918. A summary of this report is as follows:

The tests were held on a piece of road between Pelham Parkway and Morris Park Station of the New York, Westchester and Boston Railroad on the night of March 5, 1918.

The purpose of the test was to get the judgment of a large number of observers on two points: First, the illumination required to render visible a man in dark clothing at distances of 150 ft. (45.7 m.) and 250 ft. (76.1 m.) from the observer; second, to determine how much each observer would tolerate in the way of glare in his eyes from two headlamps placed 100 ft. (30.5 m.) from his own lamps and to one side of them, with his own lamps adjusted at the intensity which he required for observing the man on the road 250 ft. (76.1 m.) away.

Two pairs of parabolic headlamps were used mounted on stands. In series with each pair of headlamps was an adjustable rheostat and an ammeter. Before beginning the test the

*During the year the Committee on Automobile Headlighting Specifications rendered two interim reports, the first was presented at a joint meeting of the Metropolitan Section of the Society of Automotive Engineers and the New York Section of the Illuminating Engineering Society on April 11, 1918; the second was presented before the New York Section on November 14, 1918.

field of light in which the men to be observed would move was mapped at both 150 and 250 ft. (45.7 and 76.1 m.) from the lamps, illumination measurements being made over this entire field by means of a Sharp-Millar photometer, while the current supplied to the lamps was held at a given value. Illumination measurements at a given point were also made with other values of the current, so that the ratio of illumination change was determined. The flux density produced by the glaring lights in the observer's eyes was measured by placing a photometer on a chin rest used by the observers, and measuring the illumination at eye level. This was done at a variety of values of current. Subsequently during the test only ammeter readings together with such check photometer readings as were necessary were taken. The road on which the test was made, while itself unlighted, was more or less surrounded by a lighted area and was very far from being as dark as an isolated country road might be. The surface of the road was of a medium dark color. The conditions were static; that is, all lamps were stationary. The only moving objects observable were the men who were being observed at a distance.

Forty-nine observers who in this report are designated by number, but whose names are preserved in the records of this Committee, participated in the test. The results are summarized as follows:

	Visibility				Glare	
	150 ft. (45.7 m.)		250 ft. (76.1 m.)		[illegible]	
	Cp.	Ft.-c.	Cp.	Ft.-c.	Cp.	Ft.-c.
Average	3,200	0.142	6,980	0.112	239	0.024
Range in cp.	1,000-10,000	1,300-18,300	—	80-850	—	—
Range in ft.-c.	0.0445-0.445	—	0.021-0.293	—	0.008-0.085	—
Median values	2,500-0.11	—	6,300-0.10	—	170-0.017	—

The results obtained in this stationary test showed very wide variations in value, due undoubtedly to different individual criteria for visibility and for glare. Evidently the average values obtained could not be accepted as necessarily applying to actual conditions on the road. In fact common experience indicated that drivers were getting along fairly well with considerably less

light on the road than the average values in this test showed, and that they were putting up with a certain degree of success with more severe conditions of glare than corresponded to the average in these tests. One fairly safe conclusion to be drawn from the above results, however, seemed to be that the extreme values obtained by individuals in this test ought not to be exceeded; that is, that for visibility at 150 ft. certainly not less than 1,000 candlepower is required, and for visibility at 250 ft. not less than 1,300 candlepower. Also that at 100 ft. the glare striking the driver's eye from an oncoming car ought not to exceed that corresponding to 850 candlepower.

CO-OPERATION WITH NEW YORK STATE AUTHORITIES.

Subsequently to this test the Committee was asked to participate in framing a proposed amendment to the New York State Automobile Law with a view to ameliorating conditions in that State. Accordingly, the Committee was represented at Albany, in connection and co-operation with Mr. L. B. Marks, Chairman of the Committee on Lighting Legislation, and Mr. G. H. Stickney, then President of the Society. The New York State Law finally passed provided in substance that automobile headlights should be so mounted, adjusted and operated as to avoid dangerous glare or dazzle and that they should be sufficient to reveal a person, vehicle or substantial object at a distance of 200 ft. ahead of the car. Moreover, the Secretary of State was empowered to promulgate uniform specifications for the testing of headlight devices through a suitable testing agency, and upon the basis of the report of such testing agency, to issue a certificate describing the device and certifying that tests had been made and that the device when properly applied complies with the provisions of the law, and prescribing the maximum candlepower to be used therewith.

Secretary of State Hugo then acting through Mr. G. B. Nichols, Chief Engineer of the State Architect's Office, and Local Representative of the Society in Albany, requested this Committee to formulate the specifications under which headlighting devices should be tested to determine their compliance with the new State Law.

In the meantime the Committee had been preparing to make,

in conjunction with the S. A. E. further road tests with moving vehicles to determine the further data on which specifications could be based. These tests were consequently directed specifically toward the problem in hand in the case of New York State.

FRAMING SPECIFICATIONS

As a starting point the limiting values as obtained in the stationary test on Pelham Parkway were taken as indicating the probable limits beyond which the specifications could not go.

The question at once arose as to the glare limit. Is it to be assumed that the glare limit which applies to a car at a distance of 100 ft. would apply also to a car at a greater distance? The idea which was finally arrived at was that it would be quite proper to allow a higher value for glare along the axis of the car, inasmuch as light along the axis would reach the eyes of an opposing driver only when he is at a considerable distance. When the cars get nearer, the drivers would mutually turn out for each other and enter the portion of the beam which lies well to the left of the axis of the cars. Therefore at a distance which represents passing position at 100 ft., the glare limit should not be over 850 candlepower, whereas along the axis it may be considerably higher.

As to the height at which the glare should be measured, the consideration of the height of the average driver's eye from the road was the guiding one. This height is about 60 in. Therefore, in adjusting the headlights for the road test, the following points were measured: first, the beam candlepower in the region at which the beam would strike the road at a distance of 200 ft.; second, the candlepower along the axis and 60 in. from the ground at a distance of 100 ft.; third, the candlepower 60 in. from the ground and 7 ft. to the left of the axis at a distance of 100 ft.

Two cars were fitted with identical equipment, and by the use of commercial devices the light was diffused or directed as required. With separate storage batteries and rheostats the candlepower of the lamps could be adjusted to any required value. Photometers and screens were provided to aid in making and defining these adjustments.

WHITE PLAINS TESTS

A joint meeting of this Committee with the S. A. E. Committee was held at Gedney Farm Hotel, White Plains, N. Y., on June

3rd, 4th and 5th, with the participation of the Chairman of the Committee on Lighting Legislation. On the evenings of June 3 and 4, 1918, road tests were held.

In each test two cars were driven past each other and the observers in each were asked to note the driving light of their own car and the glare from the other. These notes were recorded by the observers on individual cards which were collected at the conclusion of the test. By this means it was expected to obtain the independent opinion of each observer.

At the conclusion of the tests the data were all condensed and tabulated as below:

A study of these results together with the results of other tests conducted by the Committee and by individuals on the Committee indicated that the minimum driving light, as given by the stationary test, was about as little as could be gotten along with with safety on a dark road and in the absence of other lights. These results indicated also what was already known; that is, with a good driving light a brighter glaring light can be endured. They showed also the utility of the plan of allowing a higher light 1° above the axis directly in front of the car, inasmuch as this higher light helps very much in road illumination and is not particularly detrimental as far as glare is concerned in the regions and at the distances at which it meets the eye of an oncoming driver.

The glare figures indicate that while with an excellent driving light, a higher glare figure might be allowed than indicated by the stationary test, yet for ordinary to good driving lights this maximum figure seemed to represent the extreme limit of reasonable tolerance.

Specifications for laboratory tests of fixed devices were then drawn up by the Committee and submitted to the Secretary of State. The Secretary of State held a hearing on June 25th which was largely participated in by manufacturers of headlighting devices, and as a result of the consideration given the Committee's specifications at that hearing, he adopted them for the use of the State with only a few verbal changes which are of no importance from a technical point of view. These specifications, which, therefore, are the specifications proposed by your Committee, are given herewith.

SUMMARY OF ROAD TESTS, JUNE 4, 1918

Beam types—1 Scattering. 3 Deflecting. Flat top high in center.
2 Deflecting. Triangular top. 4 Concentrated beam deflected toward road.

Test No.	Car	Beam type	—1°	0°	+1°	1° L 4°	As driving light	As producing glare
1	W	1	1,620	3,000	2,200	600	Fair A B C D E F H I J K Good G	Bad A B D I Fair C E G H J K At limit F
	B	2	4,300	4,400	5,000	600	Poor A C D I Good B E G Fair H I J K	Fair A C E F G H J K Bad B D I
2	Cad-1 Cad-2	4 4	Test to study the effect of tilting headlamps				Not tilted Excellent B G K Good C D E H I	Not tilted Bad B H Objectionable C I Intolerable G K Very Dangerous B Tilted Satisfactory B Good C D E F G H J K
3	W	3	2,400	1,270	[illegible]	500	Poor B C E F H Very poor D K Good G Fair I J	Fair B D I Unsatisfactory C G J Good E F K
	B	2	5,000	5,000	4,600	750	Fair B C I Good E F G H J K	Unsatisfactory B C Bad D E H I Good F Fair F J K
5	W	1	[illegible]	[illegible]	[illegible]	[illegible]	Fair B Good C D F	Fair D E I Poor J K
	B	1	3,400	5,700	[illegible]	[illegible]	Good slow driving D E I Excellent K Fair J	Bad B Objectionable E I Fair F

SUMMARY OF ROAD TESTS—(*Continued*).

Test No.	Car	Beam type	$-1°$	$0°$	$+1°$	$+1°$ L $4°$	As driving light	As producing glare
5	W	1	2,760	2,900	2,980	1,560	Poor B Good C-E-F-K Good slow driving D-I-J Fair L	Bad B Objectionable C-D-E-F-I-J Fair K Dangerous L
	R	1	1,700	1,580	1,520	1,310	Good C-E Good slow driving D-I Poor B Fair F-J-K	Bad B-F-I-J Objectionable C-D-E-L Near limit K
6	W	1	1,430	1,510	1,550		Fair C-E Poor F-I	Bad B-J Fair D-K-L
	R	1	1,100	1,060	1,000	850	Poor B-D-J Fair K-L	Fair C-E Bad F At limit L
7	W	2	11,200	4,400	2,080	850	Bad B Good C-E-F Excellent K	Bad D-J Objectionable I Fair L
	R	1	1,100	1,060	1,000	850	Poor D-I-J-L	Very bad B Fair C-E Satisfactory F-K
8	Cad.	4	32-cp. lamps. Road bright				Good B-D-L Fair I-K	Bad C-E-J
	R	1	1,100	1,060	1,000	850	Bad C Poor E-J	Passable B-I-K Satisfactory D Objectionable L
9	W	2	11,200	4,400	2,080	850	Good B-C-E-K Poor J	Passable F-L Considerable I
	Cad.	4	As in Test 8				Poor F Fair I Good L	Bad B-J Passable C-E Fair K

SUMMARY OF ROAD TESTS (*Continued*).

Test No.	Car	Beam type	$-1°$	$0°$	$+1°$	$+1°$ L, $4°$	As driving light	As producing glare
10	Cad	4	* Bad because of insufficient driving light				Fair B Bad C-D Poor E I-K	Fair B-C-D-C-I *Bad K Note—Beams from both cars pointed down so that no part of the beam over 800 cp. was projected above the 42 in. line.
11	W	2	11,200	4,400	2,050	850	Good C-E-F Fair D Excellent K	Bad B_1 Passable Good J_5 L_2
	R	2	16,000	8,400	4,000	700	Good B-J Very satisfactory I-L	Bad C_2-D_3-E_4-F_2 Moderate K_5 Notes—1. Bad up to [illegible] ft., then good 2. Bad up to [illegible] ft., then good 3. Bad up to [illegible] ft., then good 4. Bad up to [illegible] ft., then good 5. Distance good [illegible] ft. bad passing good
12	W	3	18,800	13,000	3,560	700	Fair B K Good C-D-E-J-L Very good F	Bad B K Fair C_1 D_1 E_2 F J_1 L_1
	R	3	12,600	5,800	2,240	850	Very good B J L Good C-D-E-F-K	Fair C_1-D_1-E_2-J_2-K_3-L_2 Not satisfactory B Good F Notes—1. Glare from about [illegible] ft. to [illegible] ft., then good 2. Glare at about [illegible] ft., no trouble in passing 3. Not entirely satisfactory

State of New York.

Office of Secretary of State.

SPECIFICATIONS FOR HEADLIGHT TESTS.

General Conditions of Acceptability.

For the purpose of test the intent of the New York State Law dealing with automobile headlights and providing that front lights shall be so arranged, adjusted and operated, as to avoid dangerous glare or dazzle, and so that no dangerous or dazzling light, projected to the left of the axis of the vehicle when measured 75 ft. or more ahead of the lamps, shall rise above 42 in. on the level surface on which the vehicle stands, such front lights shall be sufficient to reveal any person, vehicle or substantial object on the road straight ahead of such motor vehicle for a distance of at least 200 ft., is deemed to be complied with if the following conditions are fulfilled:

1. Any pair of headlamps under the conditions of use must produce a light which, when measured on a level surface on which the vehicle stands at a distance of 200 ft. directly in front of the car and at some point between the said level surface and a point 42 in. above this surface, is not less than 1,200 apparent candlepower.

2. Any pair of headlamps under the conditions of use shall produce light which, when measured at a distance of 100 ft. directly in front of the car, and at a height of 60 in. above the level surface, on which the vehicle stands, does not exceed 2,400 apparent candlepower, nor shall this value be exceeded at a greater height than 60 in.

3. Any pair of headlamps under the conditions of use shall produce a light which, when measured at a distance of 100 ft. ahead of the car, and 7 ft. or more to the left of the axis of the same, and at a height 60 in. or more above the level surface, on which the vehicle stands, does not exceed 800 apparent candlepower.

Conditions of Laboratory Test.

In order to determine whether any particular device conforms to these requirements, it shall be subjected to laboratory tests according to the following specifications:

Number of Samples.

Two pairs of samples of the device submitted shall be subjected to test. In the case of front glasses, the samples shall be of 9¼ in. diameter, when practicable.

Reflectors and Incandescent Lamps.

The reflectors used in connection with the laboratory tests shall be of standard high grade manufacture of 1.25 in. focal length, with clean and highly polished surfaces, and as nearly truly paraboloidal in form as practicable, and as approved for this purpose by the National Bureau of Standards.

The incandescent lamps used in connection with the laboratory test shall be of standard high grade manufacture and as approved for this purpose by the National Bureau of Standards.

Adjustments by Manufacturer's Representative

The manufacturer of the device shall be given due notice of the date and place of test. Manufacturer's representatives present at the test shall be privileged to adjust their devices in any way which represents an ordinary and legitimate adjustment, including tilting the lamps or reflectors, which can be carried out by purchasers of the device, or such adjustment may be made by the laboratory expert acting on the instructions of the manufacturer. The character of the adjustment so made shall be carefully noted and stated in the report as manufacturer's adjustment.

Tests.

The tests shall be as follows:

Test 1. Four-point test of pairs of samples.

A pair of testing reflectors, mounted similarly to the headlamps on a car, shall be set up in a dark room at a distance of not less than 60 ft. or more than 100 ft. from a vertical white screen. If a testing distance of 100 ft. is taken, the reflectors shall be set 28 in. apart from center to center, and if a shorter testing distance is taken, the distance between reflectors shall be proportionately reduced. The axes of the lamps shall be parallel and horizontal, or as tilted in accordance with manufacturer's adjustment. The intensity of the combined light shall then be measured with each pair of samples in turn, with the reflectors fitted with a pair of each of the following types of incandescent lamps, in turn.

(1) Vacuum type, 6-8 volts, 17 mscp., G-12 bulb.

(2) Gas filled type, 6-8 volts, 20 mscp., G-12 bulb.

The lamps shall be adjusted to give their rated candlepower. Measurements shall be made at the following points at the surface of the screen:

A. In the median vertical plane parallel to the lamp axes, on a level with the lamps.

B. In the same plane 1° of arc below the level of the lamps.

C. In the same plane 1° of arc above the level of the lamps.

D. Four degrees of arc to the left of this plane and 1° of arc above the level.

In an acceptable device both pairs of samples shall conform to the following specifications for observed apparent candlepower:

Points A and B. At at least one of these points the apparent candlepower shall not be less than 1,200.

Point C. The apparent candlepower shall not exceed 2,400.

Point D. The apparent candlepower shall not exceed 800.

Provided, however, that if the test indicates that a device which is unacceptable with either of the test lamps will come within the specifications with lamps of another candlepower or of the other type, the device may be passed with corresponding limitations as to the incandescent lamps to be used in connection with it.

Test 2. Complete test of single sample.

A single sample taken as an average representative of the device as manufactured, shall be submitted to a complete test with a vacuum incandescent lamp of 17 candlepower 6-8 volt rating in a G-12 bulb. This test shall show its light distribution characteristics by actual measurements made according to recognized and exact methods.

Distribution of Samples.

One pair of the samples submitted shall be retained by the testing laboratory for purpose of future reference and as samples of construction, and the other pair shall be returned to the office of the Secretary of State.

Report.

The report of the tests shall be rendered in duplicate to the Secretary of State, and shall be signed or initialed not only by the expert making the test, but also by an executive officer of the institution making the test.

It shall include a statement by the testing laboratory as to whether the device when properly applied substantially complies with Section 286 of the Highway Law and shall suggest the maximum candlepower to be used with the same, and as to the other conditions necessary in the operation of the device, in such a way that it will comply with the requirements of this specification.

FRANCIS M. HUGO,
Secretary of State.

Albany, N. Y., June 25, 1918.

COMMENTS ON SPECIFICATIONS.

In placing the specifications before the Secretary of State the following statement explanatory of them was submitted:

"The specifications for test and the interpretation of the intent of the New York State Headlight Law on which they depend are based on the following:

1. "The general principles of illumination and of glare which have been the primary subjects for the study of the Illuminating Engineering Society from the time of its foundation in 1906, and on which a great many published data are available, and also on the long practical experience of the Lighting Division of the Standards Committee of the Society of Automotive Engineers.

2. "The general practice in regulatory legislation which has been to restrict the light above a certain level above the road.

3. "The considerations and data embodied in the report of the 1917 Committee on Automobile Headlamps of the Illuminating Engineering Society (a committee for the most part of entirely different personnel from the present committee).

4. "The results of the tests held on Pelham Parkway on the night of March 5th, 49 observers of the most representative character participating.

5. "Various minor road tests held subsequent to that time to determine the applicability of the figures of the Pelham Parkway test to practical conditions.

6. "The results of extensive road tests held on the evenings of June 3 and 4, 1918, under the direct auspices of this Committee in conjunction with the Lighting Division of the Standards Committee of the Society of Automotive Engineers.

"The endeavor in the production of these specifications has been to provide for a system of testing headlight devices under uniform conditions applicable to all such devices and equally fair to all, in such a way that the acceptability or unacceptability of any individual device will be determined through exact measurements, as is evidently contemplated in the New York State Law.

"The specifications represent a serious attempt to determine the limits within which the performance of any headlighting device must fall in order that its use shall not be clearly an infringement of the intent of the New York State Law, and a menace to other users of the highway. The specifications do not represent an attempt to outline or impose an ideal system of lighting. They are frankly and avowedly influenced by the present state of the headlighting art as represented by the cars now using the highways of the State. They do not represent a theoretical solution of the headlighting problem, but are based primarily on the most practical tests which the Committee was able to devise and carry out, although it can be said in their favor that the theoretical considerations as deduced by the 1917 Committee on Automobile Headlights, bear out in a general way the conclusions here reached. They are in no sense revolutionary, and are not expected to drive from the road any meritorious device when used within proper limits. They are expected to provide a reasonable safeguard to all users of the road, and to effect a gradual but permanent and considerable amelioration of the conditions as they now exist.

"The tests called for in the specifications are founded upon so-called practical or road tests. What they are intended to do is to provide a means whereby the equivalent of a uniform road test can be given to all devices.

"The Committee found the matter of formulating these specifications a very difficult and complicated one. It is not sufficient to take a headlamp out on the road and examine it by itself in order to determine whether it gives an adequate driving light or not, and whether it does or does not produce dangerous glare or dazzle. In order to determine the latter point, the light under test must be met by observers in another car, and then their judgment of the glare is to a considerable degree dependent upon the road light on the car in which they are riding. If they have a very good road light themselves, they will stand without danger a much higher degree of glare from the oncoming car. However, within such limits of variation as are to be expected from the fact that the judgment of the observers is influenced by their individual psychology, a reasonable degree of agreement was reached after discussion of the results that the

figures given in the specifications as agreed would be the best ones in view of all the circumstances of the case. Before adopting them various other test data were examined, and in particular laboratory tests of a number of actual devices were made to see what their performance would be in terms of the proposed specifications.

"It is expected that with the universal conformity to these specifications there will be no cars which do not have a fairly adequate driving light, and there will be none which under the ordinary conditions of driving gives a degree of glare which will be such that other drivers cannot proceed with reasonable safety. Moreover, conformity to these specifications does not necessarily require the automobilist to spend any money on patented or other devices. By proper adjustment of his headlamps or by a simple expedient such as he can carry out himself, he is able to conform to the requirements.

"It is believed, therefore, that the adoption of these specifications can work no hardship on any one really desirous of conforming to the law and that the specifications having emanated from an authoritative joint engineering committee should stand.

SUMMARY.

1. "The specifications are based upon thoroughly practical considerations and practical tests, and are constructive—not destructive; reformatory—not revolutionary.

2. "They provide an equivalent for uniform road tests which are equally fair and applicable to all devices.

3. "They represent the mature judgment of a competent committee and are calculated to produce the result contemplated in the law without working an undue hardship either to motorists or manufacturers of meritorious devices."

IDEAL SPECIFICATIONS.

In further explanation of the specifications it is very important to notice the import of the following extracts from the minutes of the meeting of the Committee held on June 3rd to 5th:

"It was brought out strongly in the discussion that the specifications being put out are intended to meet existing conditions on the road, and are not intended to serve as a guide for future practice in headlight design and operation. A vote taken of four members of this Committee indicated that much more desirable limits than those included in the specifications would be as follows:

"With the beam illuminating the road at a distance of 200 ft., 5,000 to 6,000 candlepower minimum.

"With the beam 1° above the horizontal, 1,200 to 3,500 maximum.

"With the beam 1° above and 4° to the left, 500 to 800 maximum.

"In other words, it would be more desirable practice to increase the 200-ft. beam and to decrease the glare value as compared with values given in the specifications.

"The Committee also considered that the proper use of a controllable device is indicated as necessary if all the conditions of proper road lighting are to be met, and that no fixed and invariable device could meet all of these conditions. The tests indicated that controllable headlamps which are tilted down when the glare from them becomes offensive to an oncoming car are a commendable device."

It will be clear that the Committee does not consider that the work along this line is by any means at an end. It rather deems that it has made only a start toward the goal. Succeeding committees will find plenty of opportunity for experimentation in this very fruitful field.

C. H. Sharp, *Chairman*,
Percy W. Cobb,
E. C. Crittenden,
E. J. Edwards,
C. A. B. Halvorson,
M. W. Hanks,
W. F. Little,
W. A. McKay.

DISCUSSION OF THE FIRST INTERIM REPORT PRESENTED BEFORE A JOINT MEETING OF THE METROPOLITAN SECTION OF THE SOCIETY OF AUTOMOTIVE ENGINEERS AND THE NEW YORK SECTION OF THE ILLUMINATING ENGINEERING SOCIETY, APRIL 11, 1918

J. R. Cravath (Communicated): Having been one of the first to advocate the establishment of some definite specification as to the candlepower to be permitted in the direction of the opposing driver's eye or the foot-candles incident upon his eye, so that glare regulations may be made more definite, I welcomed the test proposed by this Committee as calculated to give considerable valuable information as to what limit should be placed on light emitted where it may cause glare. From one aspect the results reported are not at all surprising because those of us who have been studying the glare question in connection with street and interior lighting for many years fully realize how much interference with vision is caused even by a light of low candlepower as nearly in the line of vision as an approaching automobile head-

light must be. From another aspect the results are very surprising, because some of us who have been studying the headlight glare problem know that on busy thoroughfares at night we are frequently passing headlights, with safety, and without serious interference with vision, which give considerably more than 239 candlepower in the eye at 100 ft. Yet this is the average figure for the forty-nine observers. Or if one were to take the lowest figure of 80 candlepower selected by the most sensitive observer the results are still more surprising. To limit the glare candlepower to any such figure would require such a downward tilt of the beam as to very seriously restrict the usefulness of the headlights. When we are using devices which give a definite beam of light this question is primarily one of how much tilt shall be given to that beam. The lower the beam is tilted the less the glare in the eye and the more restricted is the distance at which objects are revealed by the headlight.

Although I approved of the method of making these tests at the time and still believe they lead to information of much value, further study of the subject and analysis of just what happens when two automobiles are meeting at night has convinced me that a standing test of this kind necessarily leaves out of account one very important factor in the problem which has not been brought out clearly in discussions of this subject as far as I know. When two automobiles are approaching each other at night with a proper headlighting equipment, there is a brightly lighted space of road between them. The road is brightly lighted for each driver by the opposing headlights. There is thus a stretch of road between the machines which is usually made very plain to both drivers. Neither driver can see past the other headlight to the road beyond. Consequently there is a brief interval just before passing when each driver must go on memory of the road that was illuminated the instant before. This all drivers do without inconvenience and without thinking about the process. It is a serious mistake therefore to assume that the glare should be so restricted that each driver can see by the other car onto the road beyond. To make any such assumption would be to restrict the headlight unnecessarily and increase rather than decrease the danger of night driving. The amount of glare to be permitted

in the opposing driver's eyes should be limited to that which will not too seriously interfere with his view of the road when it is illuminated by both headlights, and to that which will not cause such an after-effect as to make it impossible for the eye to recover quickly when it is past. When this is considered it will be seen that a driver is likely to consider tolerable a much greater candlepower in the glare zone when he is actually driving with both cars in motion than under the conditions of this test where the efforts of many of the observers evidently were to see past the other headlight to the road beyond.

In order to try out what certain candlepower restrictions as to glare would mean in actual practice I have made a few tests with a car equipped so as to give a known candlepower in certain directions in the region of an opposing driver's eye. These tests although very limited both in number and scope are submitted for what they may be worth in contributing to the solution of the problem and the drawing of satisfactory specifications.

The two cars used in these tests were equipped with a prismatic lens giving an oval beam of light about twice as wide as high; lamps of a nominal rating of 21 candlepower; and reflectors, $7\frac{1}{2}$ in. diameter, 32 in. above the road, pointed so that the headlight beams overlapped on the road. The tilt of the beam to get greater or less candlepower in the glare zone was accomplished by bending the headlight arm. Exact candlepower adjustments were made on one car only, the other being adjusted simply by inspection to give an apparently similar distribution on the road. After an adjustment was made the cars were driven repeatedly past each other on a dark asphalt street with no street lights, the test course having some level and some slightly rolling contour. Each observer drove past the tested car repeatedly until satisfied to render a judgment as to its glare. Each observer also drove a number of miles in the car over dark roads to form a judgment as to the driving light.

The technical data as to the two adjustments of headlights tested are given in Table I.

TABLE I.

Point of measurement on level road 100 ft. ahead of car.		Foot-candle (Normal) Adjustment 1	Adjustment 2
63 in. high	7 ft. to left of center line	0.051	0.080
63 in. high	On center line	.044	.116
63 in. high	7 ft. to right of center line	.051	.122
42 in. high	7 ft. to left of center line	.075	.157
42 in. high	On center line	——	.298
42 in. high	7 ft. to right of center line	——	.080
6 in. high	7 ft. to left of center line	.188	——
6 in. high	On center line	.282	——
6 in. high	7 ft. to right of center line	——	——

Adjustment 1 was pronounced satisfactory as to glare by three drivers after the repeated meetings described. Four drivers pronounced this adjustment a very satisfactory driving light after driving behind it a number of miles on dark roads.

Adjustment 2 was pronounced by the same three drivers as a little more than they would like to stand for in the way of glare. Although they were able to drive past it without much difficulty all felt that it was approaching the danger limit. Later this same car was stopped by a policeman on one of Chicago's level boulevards and the driver told to fix his headlights when he got back to the garage.

In connection with specifications for headlight glare it is of interest to note that the first attempt at a definite candlepower limitation in the glare zone has been made by Commissioner C. M. Talbert, of the City of St. Louis, who has motor vehicle matters under his charge. At the municipal automobile headlight testing station which he has established for the use of motorists a limitation of 1,200 candlepower above the 42 in. level or 0.75 foot-candles at 40 ft. distance has been established for glare. A minimum limitation of 500 candlepower to reveal objects on the road at 150 ft. distance has been established.

With appliances now on the market it is entirely possible to produce a satisfactory driving light without dangerous glare if the motorist is willing, as he should be, to confine himself to speed not much over 20 miles per hour. While the glare from such headlights may be somewhat annoying it is not really dangerous and for the present will have to be put up with for the

sake of securing a fairly good driving light. The man who wants to exceed safe and legal speed limits and have light enough on the distant road to reveal obstructions in time to stop will probably have to let his desires remain unsatisfied for some time to come.

L. C. PORTER (Communicated): It is shown that the average foot-candle intensity required by the various observers to enable them to distinguish a man at 150 ft. was 0.143, while that required to distinguish a man at 250 ft. was 0.112. In other words, less than that required at 150 ft. I presume there was some local condition to explain this apparent anomaly. It would be interesting to know what those conditions were.

There have been various tests made from time to time on the intensity required to enable a man to be seen at different distances. As nearly as I can determine these tests show that about 1/10 of a foot-candle is required to make a man visible at 1,000 ft. If further tests are to be conducted with the elaborate set-up provided for these tests, it would be a fairly simple matter to add a series of tests determining sufficient data from which to plot a curve showing the intensity required at various distances under fixed conditions of contrast, etc., and I think that such data would prove quite valuable.

We have probably all observed that in broad daylight we can look into a pair of lighted automobile headlights with a fair amount of comfort; that on a brightly lighted street at night powerful headlights are not nearly so glaring as on a dark country road. In other words, interference with vision depends, to a large extent, upon the contrast between the light source, *i. e.*, the automobile headlamps and their immediate surroundings or background.

Some time ago the thought occurred to me that it might be possible to have each automobile carry with it means of placing itself in an illuminated background. In other words, take along a street lighting system as it were. In order to test this out, Wednesday, September 12, 1917, I equipped my machine with two 36-candlepower headlights without any glare reducing device and in order to make the conditions as hard as possible, conducted tests on a green grass field using for an object a person

wearing a dark rain coat. The machine was also equipped with four 21-candlepower lamps without reflectors. One under the center of each running board, one under the center of the front axle and one on the rear license tag. These lamps would thus illuminate the ground for some 15 ft. surrounding the machine and anybody within that area. In other words, placing the machine in the illuminated background. With the headlights only burning, it was not possible to detect, from any distance greater than 10 ft. in front of the machine, a person standing 5 ft. to one side of the machine opposite the front axle. With the underneath lights turned on this person could be detected from a distance of 100 ft. in front of the machine. With the observer standing 50 ft. in front of the machine, the test object could be distinguished 10 ft. to one side of the machine.

Further tests indicated that the lamps on the rear license tag and the front axle added little and that a better location for the lamps under the running boards was on the sides of the body of the machine at the height of the top of the seat back.

The lamps in this location were finally equipped with wide angle reflectors and proved most effective. In addition to enabling the driver of an approaching car to see past my car, these side lights made driving much pleasanter. There was not the usual sharp cutoff from the headlights. I found it very pleasant to be able to see the ground directly to each side of the middle of the car.

Lighting equipment for placing the car on an illuminated background could easily be built into the body of the car, in a very neat manner. Switches could be arranged to control these lamps independently from the headlamps, if so desired.

The accompanying photos were taken with the camera in the position of the driver of an opposing auto, at a distance of 50 ft.

G. H. STICKNEY: The test covered by this report represents a step on the part of the Society toward determining a scientific and practical basis for automobile headlighting specifications. While our committees have been working on the problem for some time, this particular test was run for the purpose of assisting the Committeemen of the New York Legislature, who solicited our advice in their desire to secure the enactment of a more

Fig. 1.—Headlights only burning. Test object standing in exactly the same position as in Fig. 2.

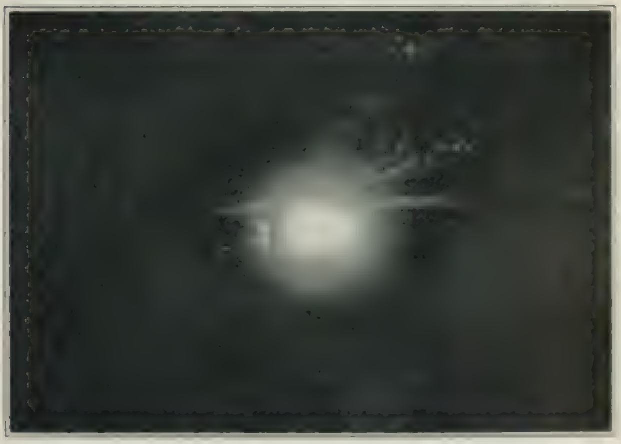

Fig. 2.—Headlights and lamps on side of machine both burning. Test object [illegible] ft. from front axle of machine. Fence post on right [illegible] ft. from machine.

effective law. The question was taken up by the Chairmen of our Committees on Automobile Headlighting Specifications and Lighting Legislation, and the test run in co-operation with the Standards Committee of the Society of Automotive Engineers. Dr. Sharp, Mr. Marks and myself had the privilege of attending a committee hearing in Albany, in which the bill was discussed.

It is apparent that the problem involves matters of practical automobile operation as well as those of illuminating engineering; for example, while the determination of the intensity necessary to see defined obstacles at given distances, will unquestionably fall within the field of our committees, the determination of the necessary distance, the definition of obstacles, etc., are matters of automobile operation. We were very fortunate in having the co-operation of the Automotive Engineers.

The proposed law, as called to our attention, defined certain of these general factors, but described them in such terms that no definite or measurable lighting values could be applied to them. The test was an attempt to verify these specifications and assign numerical values to them so far as the limitations of the test permitted.

The result indicates clearly the indefiniteness of a descriptive visibility specification without actual illuminating engineering units. Although limited to a single condition of road service, weather, etc., we find in the group of fifty observers, intensity readings varying over ten to one, and could hardly expect to avoid even a wider variation among different groups of people in different locations and with different weather conditions. It, therefore, seems that any ultimately satisfactory specification must involve values in foot-candles or other units of light.

On this basis our committee chairmen recommended, at Albany, the adoption of the lowest intensity and highest glare values found acceptable in the test. While these values seem likely to be too liberal to be ultimately satisfactory, they would certainly be more definite than any other practicable description now available and would leave an opportunity for the adoption of closer limits when further tests and experience might indicate their practicability.

We found that lack of general familiarity with lighting units

made it impossible to have such values incorporated in the law. It is understood, however, that the law, if passed, will empower the Secretary of State to secure advice and determine on specifications both for devices and their operation.

DISCUSSION OF THE SECOND INTERIM REPORT OF THE COMMITTEE PRESENTED BEFORE THE NEW YORK SECTION OF THE ILLUMINATING ENGINEERING SOCIETY NOVEMBER 14, 1918.

L. B. Marks: It is to be hoped that the New York State law in relation to headlighting will furnish a basis for other state legislation that will follow shortly. At the present time there are eight states that are actively considering automobile headlighting legislation. Perhaps you will recall that last year there was an automobile headlighting law in New York State. After a trial of one year this law was considered a dead letter, because it could not be enforced. It could not be enforced because it did not contain a numerical interpretation of dangerous glare or of the light required to see an object a stipulated distance ahead of the car. When this law was amended last spring, representatives of the Illuminating Engineering Society urged Senator Hewitt, sponsor for the amended bill, to include such numerical interpretations, which were furnished by the I. E. S. Committee on Automobile Headlighting Specifications. The first draft of the amended bill contained these numerical interpretations, but upon objections raised at a public hearing in Albany it was held by the law-makers that the numerical interpretations did not constitute proper matter for a substantive part of the bill. Accordingly these values were stricken out of the bill. However, they were retained in a specification to which reference is made in the following section of the law:

> * * * The Secretary of State shall upon notice to the manufacturer (of headlighting devices), submit such device upon such uniform specification as he may from time to time prescribe and promulgate, to the United States Bureau of Standards or to any duly qualified testing laboratory * * * with a request that it be tested as to its compliance with the provisions of this section; and the Secretary of State may also submit such device to such practical road test as he deems proper. Upon notice (from the above bureau or laboratory) that such test has been made and that such device when properly applied, substantially complies

with the provisions of this section and suggesting the maximum candlepower to be used therewith, the Secretary of State may issue a certificate to the applicant describing the device and certifying that such test has been made and that the device when so applied, complies with the provisions of this section and prescribing the said maximum candlepower to be used therewith.

The specifications above referred to, which were prescribed and promulgated by the Secretary of State, were prepared by the I. E. S. Committee on Automobile Headlighting Specifications. The tests prescribed were made for the State of New York by the Electrical Testing Laboratories. Thereafter the Secretary of State issued certificates to manufacturers of forty-five lenses and automobile light controlling devices listed in an official publication of the Secretary of State dated Sept. 9, 1918. In this publication the maximum permissible candlepower of lamps is prescribed for horizontal and tilted beam, type B and type C lamps.

The Secretary of State addressed the annual convention of the Society in October, 1918, and intimated then that certain departures had been made upon his own responsibility from the recommendations of the laboratories with respect to maximum candlepower permissible. By permission of the Secretary, I examined the reports at Albany, submitted by the laboratories and noted discrepancies between these and the Secretary's published list of September 9th as follows:

	Maximum permissible candlepower				
	Beam horizontal B lamp	Beam horizontal C lamp	Beam tilted B lamp	Beam tilted C lamp	Tilt ft. per 100 ft.
Warner Lenz:					
Laboratory report	7	6	—	—	—
List issued by Secy. of State	—	24	—	—	—
Dillon Lens:					
Laboratory report	6	6	6	6	—
List issued by Secy. of State	10	—	—	—	—
More-Lite, Clear:					
Laboratory report	7	6	—	—	—
List issued by Secy. of State	10	—	—	—	—
No-Glare on Bulb:					
Laboratory report	5	5	—	—	—
List issued by Secy. of State	—	—	17	15	1

The Secretary stated that some of the departures from the

findings in the laboratory reports were based upon road tests made by him or by his direction; further that departures other than those listed above, were made by him. The exact nature of these road tests was not revealed. In view of the wide discrepancy between these and the road tests made by the Committee on Automobile Headlighting Specifications, upon which the standards fixed in the specifications were based, it is evident that a mistake has been made by someone. The Secretary of State has expressed his desire to co-operate with us in every way possible. It is up to us to help him all we can. He has expressed his willingness to participate in a road test of the headlamps in question to be made under the auspices of the Committee on Automobile Headlighting Specifications, and an invitation to do so will be extended to him shortly.

In the meantime, may I suggest that written complaints containing specific information be addressed to the Secretary of State by those who encounter automobiles on the road, equipped with headlamps that give dangerous glare.

I come here to-night to urge upon you the importance of taking such steps as may be necessary to prevent the present New York State law on automobile headlighting from falling into disrepute. Why is it that some of these headlighting devices are allowed 24 candlepower and others only 10 candlepower in practically the same type of lens, with the same adjustment? It is for us to show what is right and to insist upon the right thing being done.

G. H. Stickney: The auto headlighting problem is a very difficult one. The best practice falls further from daylight, in point of safety, than almost any other application of artificial light. There is, however, a wide variation in the effectiveness of the different practices now prevailing, and it is highly important that efforts be directed toward securing the safest possible conditions, and eliminating at least the most dangerous.

The first step should be to secure a definite expression of what is desirable and what is dangerous, in terms which can be identified with reasonable accuracy. To specify "intensity" in terms of that necessary to see a person at a particular distance—say 800 ft., as in railway headlight regulations—is not definite enough for frequent individual determinations, as such observations are

subject to so large a variation. This was evidenced in one of the early tests of our Committee, where with fixed conditions, variations as high as ten to one were obtained between individual observers. With different weather conditions, backgrounds, etc., much wider variations may be expected.

The better method is to make a thorough and careful investigation under practical road conditions, and thus determine the necessary intensity in measurable values. Even if later experience should render a modification of the values desirable, it would introduce no serious hardship, while the specification would be fairer to all concerned and more definitely enforcible.

Now, this is what our Committee undertook to do. Those who are unfamiliar with light measurements, may not realize how well such results can be recorded, and perhaps Dr. Sharp has not made it clear how much effort was made to eliminate error or prejudice on the part of observers. While the public is entitled to preference, even if some loss is incurred by equipment manufacturers, it is essential that the equipment manufacturers should have equal and fair treatment. An indefinite specification leaves so much to personal judgment, under particular conditions, that equality is difficult to assure.

It is my understanding that the values determined by Dr. Sharp's Committee are liberal rather than otherwise and give the benefit of the doubt to lighting which is questionable but not a serious menace. It may be desirable, with the development of the art, to make them more stringent at a later date.

While any specification should be based on road tests under a comprehensive series of practical conditions, it is unfortunate that the law permits the specifications, so founded, to be set aside by a single practical road test on a particular device. Even the fairest observer is liable to be misled by a few observations of this sort. If such a road test leads to conclusions which do not accord with the specifications, it is evident that one or the other is unreliable. If the individual road test is incorrect, it should be discarded. If it were correct, the specifications certainly would need amending. But, since the tests for determination of the specifications included such road tests as should be given an individual device, it seems to be entitled to the preference

I have had a feeling that some people place too much emphasis on the commercial features and not enough on the safety of the public. Having recently been in an automobile accident in which my own children were in danger, I have perhaps a strong feeling in this matter, and vivid conception of the destructive power of a heavy, fast-moving automobile.

If any lighting regulations can prevent or minimize accidents, they should receive precedence over all ordinary affairs. The danger of ineffective headlighting was impressed on my mind last night as I rode 30 miles through the rain on winding roads of eastern Massachusetts. Our headlights spread a beautiful illumination on the foliage and nearby parts of the road. They were so glaring as to rouse evident objection from those that we met, and yet there was not sufficient light to reveal the road ahead satisfactorily. In fact, the nearby objects were so bright that those more distant were rendered less visible by contrast. So ineffectual was the lighting that we nearly ran into a horse that had strayed into the road. Further, any considerable increase in the power of the lights would, in my opinion, have been a serious menace to any automobile that we met.

Although this type of lighting with high power lamps is quite popular with drivers, it is in my opinion dangerous to others and should be restricted for their protection.

The only possible safeguard seems to be an inflexible scientific specification based on the best practical understanding of the conditions of driving and the laws of light and vision.

J. R. Cravath (Communicated): This report marks a great advance in automobile headlighting specifications to prevent glare and to give adequate road lighting, and is along the lines upon which there has been an urgent need for unbiased information for some time past.

The plan of these final tests, *viz.*, that of actually driving as in practice toward headlight beams of known candlepower characteristics and getting the consensus of opinion of a number of unbiased observers as to the tolerable or permissible amount of glare, is, in my opinion, the only correct plan yet suggested for determining this point. I have in previous discussions called attention to errors which are inherent in other methods which

have been tried. We now have some definite figures for the guidance of legislators and those who are put in the position of interpreting laws already passed. The Committee's report shows about what may be considered a "dazzling" or "blinding" light, so that even where headlight laws use these rather indefinite terms, those charged with the interpretation of them have the careful work of this Committee for assistance.

A. W. SEAMAN: If we go back to the Legislative Committee's report prior to the original law of 1917, we will find that the first proposition laid down in the report was, that the safety of the driving public and the safety on the highways of everybody, was the primary purpose to be attained.

Judging from the tenor of the report that we have heard it would seem that the primary object of the specifications has been to eliminate glare. Going back to the law again: the law provided, as amended last spring, that there should be sufficient light at a point 200 ft. ahead of the vehicle to reveal a person, vehicle or substantial thing and also at a point to the sides of the car 10 ft. to the right and 10 ft. to the left of and 10 ft. in front of the lamps.

As the specifications were originally prepared, the limitation of the light was not confined to the left of the axis of the car. As the specifications were finally adopted and approved by the Secretary of State, everyone of the points were, where the light was limited, to the left of the axis of the car.

In their anxiety to make the man you meet on the highway safe they have apparently overlooked the fact that the driver is on the road all the time, while the man you meet, you are meeting only occasionally. In other words, the driver must have sufficient light to see what is on the road. He does not need the light under his nose but at a point 250 ft. ahead of him.

I am expressing no opinion as to whether a diffused or scattered ray or a direct ray light is the better.

There is another point in this law in which you will find that where no attempt is made to break the force of the rays, the limitation of candlepower is a 24-candlepower bulb. This is subject, however, to the qualification that there must be no dangerous glare to the left of the axis of the car higher than 42 in.

To the right of the axis of the car, if a clear glass is used, the only limitation is a 24-candlepower light.

Do you think that, while permitting a person who made no attempt to break the rays of the light to use a 24-candlepower bulb, if he sought to control the light rays and used a light of less intensity, the legislature intended that he might be limited to the use of a 7-candlepower bulb? Not for one moment could such thing have been contemplated.

To the right of the axis of the car the only limitation is 24 candlepower.

Another thing: the tests were made in the laboratory. The car is used under varying conditions of travel, what is a dazzling light at one time may not be a dazzling light at another, depending entirely upon the atmospheric conditions.

In the effort to be technically correct, they have apparently lost sight of the plain requirements of the law.

It has been reported that in the State of Massachusetts there have been more accidents from the want of light than from the use of dazzling headlights.

Don't think that I am in favor of dazzling headlights. They have no place upon the highway at the present time.

But before you write to the Secretary of State asking him to limit the power of bulbs to be used in the various lights, in accordance with the report of the Committee, let us be sure that that report was based upon a correct understanding of the law.

NORMAN MACBETH: I agree in part with Mr. Seaman. But not that the laboratory work of the Committee on Automobile Headlighting Specifications was too technical. I believe if they failed it was because they were too practical. It is my opinion that if the laboratories had been technical only, they would have thrown out all diffusing devices which, when restricted to a low candlepower bulb to come within the glare limits, did not also furnish sufficient illumination at the 200 ft. point.

The press and the general public will hold the Society and the laboratories responsible for the law insofar as has to do with the candlepower and glare limits, and the approval or not of devices offered for sale and used as approved by the Secretary of State. In the New York *Times* of September 15, 1918, it was stated to

the effect that Secretary of State Hugo had issued a list of forty-five lighting devices which may be legally used on automobiles to comply with the new anti glare law. "All of these devices have passed the laboratory tests provided for in the bill, and motorists may obtain a list of these from the Secretary's office These approved lenses have been tested for specified candlepower and for the proper tilt, etc."

Secretary Hugo at the recent Society convention made the statement that there were two ways of accomplishing results, one by education, and the other by drastic legislation, and I assumed that he considered it drastic legislation to approve a certain lens for use and not approve some other lenses. He stated his desire to be practical and to co-operate with the authorities of the State in bringing about an educational movement to correct the ills of present day headlighting. I understand that he did not favor the disapproval of devices deemed dangerous under the interpretation of the law by lighting specialists or those technically qualified to pass upon what, in the opinion of many, is a practical problem. Surely he does not maintain that legislation must not be called upon to put a criminal out of business; that we should not lock up the burglar but should educate the householder to always lock his doors and windows and use barbed wire to keep the porch climber down.

In the electric lighting field where in wiring and fittings approved devices only can be used, and only in a somewhat workmanlike manner, certified to by inspectors on the job, what kind of construction would result if everything any manufacturer submitted was approved and the underwriters and city electrical department endeavored to insure safe wiring through the education of the building tenant or owner?

He went on to say that any increase in candlepower over the report of the tests issued prematurely on September 9th were up to him; that the law definitely fixes the maximum candlepower of the bulb as 24 candlepower unless the Secretary of State desires to increase it and he assured us that he had no such desire. He seems to have overlooked, or at least not shown an understanding of the intent of the law in limiting dangerous glare. The maximum candlepower of the bulb is a factor, but only of minor importance to that of the effect on this initial light quan-

tity of the reflector and lens or light distributing devices used on the headlamps. With good reflectors and plain front glasses, using only 20-candlepower bulbs, 16 per cent. under Mr. Hugo's maximum, a beam candlepower of 300,000 can be directed down the road. Enforcing a 24-candlepower maximum size of bulb does not take into consideration the evil possibilities of such a beam intensity when scattered by a diffusing front glass, with too much light directed into the eyes of approaching drivers.

The so-called practical road tests are most difficult if not impossible, particularly if any of the parties to the test are interested commercially and have glare hardened consciences and the judges have enjoyed a good dinner and are taking road observations with eyes that are not thoroughly dark adapted, but have been affected by the red glowing end of a good cigar, or worse by several lighted matches used to keep an indifferent cigar alight. These conditions are not present in laboratory tests.

It is my opinion that this Society is thoroughly committed to go through with whatever tests, investigations or reports may be required in affording the Secretary of State the necessary assistance. While many of the members confine their statements to technical language, it does not mean that they do not own nor drive automobiles, nor that they are incapable of conclusions just as practical as the man who drives and can think of light solely in terms of the candlepower designation on the neck of the bulb.

There is another point to which attention should be directed. I note that one of the diffusing device manufacturers restricted in the first or prematurely issued sheet to 10-candlepower bulbs because of the glare limit, afterwards securing the approval of the Secretary of State to use 17-candlepower lamps and advertised that this particular device having been approved for use with a maximum of 17 candlepower resulted in such a wonderful road light that auto owners would certainly not be justified in using any other lens with a higher candlepower lamp and the consequent greater power demand. The inference was that the state authorities had passed upon this advertiser's device as being adequate for road illumination with only 17-candlepower bulbs, so why use any other device which must be inferior if it is approved for use with 24-candlepower bulbs? It should be made clear that all low candlepower ratings were in the attempt to

keep the glare within permissible limits, and that any device given a low candlepower rating would probably result in an unsatisfactory road illumination for the driver of the car using the low candlepower bulbs.

I feel that this Committee is entitled to a great deal of credit for the advances made so far, and hope that every encouragement will be extended for the full completion of its plans, also that the Secretary of this and other States interested in antiglare laws may be convinced of the thoroughly practical results so far obtained.

A. W. SEAMAN: The specifications are protecting the other fellow and making the driver endanger the rights and limbs of those with him.

I will concede that I was under the wrong impression as to what the purpose of the test was. As I recall the law, anyone who has a device which he claimed complied with the requirements of the law, might submit it to the Secretary of State together with a fee of $50, who in turn, turned it over to certain laboratories, of which this Society was one, and they, in turn would determine whether the device did or did not comply with the law.

That has been my impression as to what the law said might be done. That is my impression what the meetings at Albany intended to do when we gathered to prepare specifications by which the devices were to be tested, as to whether they did or did not comply with the law.

One of the requirements of the law was that it should give sufficient light to reveal a person or substantial object or a vehicle 200 ft. directly in front.

We have just been told that their test was to determine whether it did or did not produce dangerous glare. I submit that on their own statement they did not comply with the requirements of the law.

G. H. STICKNEY: There seems to be an erroneous impression as to the relation of the Society to this question. The Society has had nothing to do with the acceptance tests conducted by the Electrical Testing Laboratories. The confusion is natural, as

some of the men associated with the Laboratories are quite active in the Society.

The Society's Committee on Automobile Headlighting Specifications, under the chairmanship of Dr. Sharp, ran the road tests and prepared the specifications. The Society's Committee on Lighting Legislation, of which Mr. Marks is chairman, cooperated in presenting the matter at Albany. But, on the adoption of the specifications, the Society's function ceased.

So far as I know, the Society has no relation to the tests which the Laboratories have made for the State of New York, except that it is interested in seeing its efforts effectively applied for the benefit of the public.

PRESTON S. MILLAR: If I understand a previous speaker correctly, he fears that the report of the Committee, through overemphasis of the technical aspect of the glare question, has failed to provide for adequate visibility of driving light. I believe that the law states that there shall be sufficient driving light to reveal a substantial object under stated conditions. To provide that sufficient driving light was I believe one of the first cares of the Committee. A group of well qualified men undertook to make a careful determination of this quantity on the road. When their determination of this quantity was completed and further trials were made, it was found that the limitation under the law would as a rule arise in connection with glare since most commercial devices provided sufficient driving light to meet the requirements of the law. With minimum adequate driving light and with maximum permissible glare determined on the road, the laboratory tests have provided data upon which approval of each headlight device could be based.

H. L. REED: This subject is very interesting, but I am afraid it is getting into a technical place where we may have trouble in the future. One gentleman said that he did not drive a car, but occasionally drove with others and that a short time ago a diffusing lens nearly caused an accident. There is the trouble. It was intended that there should be sufficient light to reveal an object 200 ft. away. Most of the other states have 250 and 300 ft. It was at my suggestion that the length was cut down from 250 to

200 ft. There should be sufficient light and this should be the prime object instead of the glare. With a 24-candlepower lamp, I do not think we will have much trouble in that respect. Writing to the Secretary criticising the uses of some lens is not going to do a bit of good. We should get the matter straightened out among ourselves. If a man violates the law arrest him after a reasonable notice. There are many other features in the law that are essential. For instance, there is more danger in meeting a man with one light than meeting a man with intense glare and that seems to be a bad practice among many drivers to use one light in order to get more power.

E. H. HOBBIE: As Mr. Reed put it we are getting to where we started from by eliminating all provision for eliminating glare which as I see it is the chief object of the law. As a manufacturer of lenses it is rather an uncomfortable position to put me in. I do not see whether any diffusion lenses can be used or not. From the specifications I should say that there was only one thing to do and that is to accept the deflecting lens as the only proposition to do the trick. Because with the diffusing lens and 24 candlepower to see the road 200 ft. ahead you would blind the man that is coming toward you.

C. H. SHARP: I can take care of my own driving light. Out of self interest I will see that it is adequate. But I cannot exercise any control over other drivers. If they molest me in my rights by the use of dangerously glaring headlights I can demand protection from the only agency competent to grant such protection, namely, the State. This right is recognized in the headlight law and the duty is imposed on the Secretary of State to take measures to ensure such protection. In so doing he protects an otherwise defenseless public and this to my mind is the most important feature in the law.

Now as to the adequacy of the driving light under the Committee's specification. The law says that you must have a light that will enable you to see a person at a distance of 200 ft. But it does not say anything about conditions under which you are to see him. It does not say whether the person has a white suit of clothes or a black suit. If a man wears a black suit and he is

on a black, oiled road, there isn't a light made that will enable him to be picked up with certainty.

A soldier in khaki against a background of autumn foliage is almost invisible at 200 ft. The reason, which all illuminating engineers recognize, is that we see by contrast. The black suit against the black road presents no contrast, and we do not see it; the same with the khaki suit. What does the law mean? To me it means that the light must be of sufficient power so that driving under reasonable conditions, it is possible to pick up an object 200 ft. away, and our Committee found that the candlepower must be at least 1,200 in order to enable that to be done. It must not be less than 1,200, or it will not qualify under the terms of the law. It is desirable that it should be very much larger.

We all know that there are certain headlighting devices that are well designed to produce the maximum driving light with minimum glare, and there are others which are not well designed for that purpose. There are efficient devices and inefficient devices. The law does not say that you must use the most efficient device, but that you must have enough light and must not produce dangerous glare. It is just as positive in forbidding dangerous glare as it is in commanding a certain minimum driving light. It certainly does not permit the user of an inefficient device to increase his candlepower sufficiently to enable him to drive, no matter what the effect is on other drivers.

The Committee was asked to make specifications according to which tests could be made. The Committee made these specifications according to its best knowledge and ability, and submitted them to the Secretary of State. Having turned them over to him, its responsibility ceased. It has been said that the Committee has fallen down. In what respect? Are not the specifications right? Probably they are not quite right. They may not be the best that there is, but that at least is something which has not as yet been proved. The Secretary of State adopted the specifications. He instructed a testing organization to test according to these specifications the headlighting devices submitted to him for approval; and this was done. The numerical results of the tests were transmitted to the Secretary of State in formal reports. If the Secretary of State in the exercise of the discre-

tion which the law gives him has adopted certain results which are not in accordance with the findings of the test, that is not the responsibility of our Committee; that is not the responsibility of the testing organization; that is the responsibility of the Secretary of State. Now before you can say that these specifications have not produced the results that are desired on the road, you have to look further and see what the administration of the law has been, whether the specifications have been adhered to. If they have not been adhered to, you cannot blame the specifications. If they have not been adhered to, you have to concede that the specifications have not had in all respects a fair chance. A fair and adequate trial is something which we feel that we have a right to ask for and to expect to receive.

A. W. SEAMAN: It must be sufficient light to reveal any persons or objects. I am not criticising the Society. Never for a moment have I intended to criticise the Society. I have worked in Albany with them. We did not agree. We had a two-day session in preparing the specifications. As prepared in the first instance, they were not satisfactory to motor users.

I represented the New York State Automobile Association and on their behalf I objected to them, and at the suggestion of Secretary Hugo the words "to the left of the axis of the car" were inserted so that the specifications, in regard to glare was limited to the left of the axis of the car.

We do not appear to be talking upon the same question. You are talking on the question of general headlighting and I am talking on the construction that has been placed upon the specifications, both by the Society and the Secretary of State. The specifications limited the question of glare to the left of the axis of the car.

In its application as it has come out from the laboratory and reported to the Secretary of State it has been construed to cover the entire area in front of the lamp. That is why I am talking to-night. You do not get the car test. I am not questioning as to whose fault it is, nor blaming anyone. What I am criticising is the situation that has developed and how it affects the operation of the car.

NORMAN MACBETH: I would like to ask Mr. Seaman if he would have any objection to using a device that was approved for use with a lamp of sufficient size to give him a good driving light, while it also resulted in a condition of lessened glare and safety for approaching drivers, or whether he insists upon the use of a diffusing device which scatters light over all outdoors and is therefore limited to a low candlepower bulb for safe driving. That he insists on using these diffusers with high candlepower bulbs to give him a light well down the road while at the same time he temporarily blinds all those who desire to travel in an opposite direction.

A. W. SEAMAN: As I understand your question it is whether I would approve of a light, sufficient to enable one to drive safely with glare or whether I would suppress all glare even though it might result in an unsafe light. I will answer that question frankly. If I were compelled to decide between a light which was sufficient to enable one to drive with safety even though it was necessary to have some glare or to use a light which, while eliminating all glare did not give sufficient light to enable one to drive with safety, then I say, by all means use the light that gave out glare, for this reason: from the time you start on the road to the end of your journey you need the light all the time. The chances of your meeting somebody else are problematical.

In other words, you must be willing, in order that you may have the benefit of a proper and safe light to give the other fellow a light similar to yours.

You must be willing to be inconvenienced to the extent that it is necessary, in order to have a safe light and the other fellow must also be willing to suffer the same inconvenience that you are required to suffer, that you may have as safe a light as it is possible to have.

If it is necessary to make your choice between glare and sufficient light and no glare and insufficient light, I say take the glare every time.

NORMAN MACBETH: There was a large percentage of the devices approved that gave a good driving light without glare, but I understood that you rather insisted on taking the lights

with glare, increasing same to a dangerous limit necessary to give you the road illumination considered safe for yourself.

A. W. SEAMAN: I expressly said I expressed no opinion whatever in regard to devices. My purpose was not to say anything for or against any device.

As I served on the Legislative Committee, which made the report and drew the law, I felt that I was obliged to be absolutely neutral between the diffusing and deflected ray lights.

What I have been fighting for, for years is a proper, safe, driving light with the least danger to the other fellow. If one device will not give a proper light and another will then by all means take the one that will, and if the man who has a device that cannot meet the requirements of the law and specifications, in other words, if he cannot give you a proper and safe light, let him try some other business that he can continue to better advantage.

F. M. FEIKER: Unless there is some other discussion it seems to me that the remarks of Mr. Seaman have summed up the matter. We ought to work for some standard that would give a good light and at the same time protect the public.

PROPOSED REGULATIONS FOR INCORPORATION IN A MODEL LAW IN REGARD TO HEADLAMPS ON MOTOR VEHICLES.

BY L. B. MARKS, CHAIRMAN COMMITTEE ON LIGHTING LEGISLATION.

The formulation at this time, of regulations for incorporation in a model law in regard to headlamps on motor vehicles, grew out of requests to the Society from eight states to furnish a working basis for the immediate enactment of state legislation on headlighting.

Before preparing the proposed regulations, a critical study was made of all of the laws on this subject now on the statute books of the various states. Joint meetings of the Committee on Lighting Legislation and the technical Committee on Automobile Headlighting Specifications were held for the general discussion of this subject with representatives of the Society of Automotive Engineers, the American Automobile Association, Bureau of Standards, manufacturers of automobile headlighting devices including lenses of the deflecting and diffusing types, state and municipal officials connected with motor vehicle departments, and other bodies and individuals who have made a special study of this subject. Among some of the questions discussed at these meetings were the following: Should the law require use of headlamp devices of approved types, or should the performance of individual headlamp devices be the criterion? Should public testing stations be established for road tests of headlights when required, irrespective of whether certificate of approval for headlamps has been issued? Should approval of types be based on tests as is done in New York State at present? Should the law base the strength of the beam required on the visibility of objects on the road? Should glare restrictions be confined to the portion of the beam to the left of the axis of the car? Should adjustments under the control of the driver, such as dimmers, tilting headlamps, etc., be allowed or recommended? Should the law contain a maximum candlepower specification? What regulations are required to cover the case of electrical systems of

excessive voltage range with speed of engine? Should the use of "spotlights" be permitted, and if so, under what restrictions?

Subsequently the Committee on Automobile Headlighting Specifications, under the chairmanship of Dr. C. H. Sharp, submitted to the Committee on Lighting Legislation proposals upon which to base a model law. These proposals contain several new ideas not heretofore incorporated in automobile headlighting legislation.

The proposed regulations submitted herewith were approved by the Council on Feb. 13, 1919, and speak for themselves. Section 6 of the regulations relates to uniform specifications and instructions to be promulgated by the Secretary of State or other proper administrative official. The technical committee is prepared to furnish these specifications and instructions and also to furnish general instructions for headlight tests at public testing stations provided for in Section 7.

FEBRUARY 11, 1919

PROPOSED REGULATIONS FOR INCORPORATION IN A MODEL LAW IN REGARD TO HEADLAMPS ON MOTOR VEHICLES.

ISSUED BY THE COMMITTEE ON LIGHTING LEGISLATION OF THE ILLUMINATING ENGINEERING SOCIETY.

Based upon Proposals of the Technical Committee on Automobile Headlighting Specifications of the Illuminating Engineering Society.

1. Every motor vehicle operated or driven on the public highways of the State at any time when there is not sufficient light to render clearly discernible a person, vehicle or other substantial object on the highway at a distance of 200 ft. ahead, shall be provided with a headlamp or headlamps of sufficient power and so adjusted and operated as to enable the driver to proceed with safety to himself and to other users of the highways under all ordinary conditions of road and weather. All motor vehicles, excepting motorcycles, shall display at least two headlamps of approximately equal candlepower mounted on opposite sides, which will on a level road render clearly discernible a person, vehicle or other substantial object 200 ft. directly ahead of the motor vehicle and will at the same time render clearly discernible an object 100 ft. ahead and 7 ft. to the right of the axis of the motor vehicle; excepting that for motor trucks which are so governed or mechanically constructed or controlled that they cannot exceed a speed of 15 miles an hour, the headlamps must render clearly discernible a person, vehicle or other substantial object 50 ft.

directly ahead of the motor vehicle and must also render clearly discernible a person, vehicle or other substantial object 25 ft. ahead and 7 ft. to the right of the axis of the motor vehicle.

2. Motorcycles shall be provided with at least one headlamp which will on a level road render clearly discernible a person, vehicle or other substantial object 100 ft. ahead of the motorcycle.

3. The headlamp or headlamps on motor vehicles shall be so arranged, adjusted and operated, as to avoid dangerous glare or dazzle, and so that no dangerous or dazzling light, projected to the left of the axis of the motor vehicle, is cast in the eyes of a driver of a vehicle approaching in the opposite direction.

4. Adjustable headlamps in the control of the driver may be used subject to the restrictions in Sections 1, 2 and 3. "Spotlights" may be used subject to the restrictions as to glare or dazzle in Section 3.

5. Any person may submit to the Secretary of State for approval, types of headlighting equipment, together with an application that such devices be tested as to conformity with the provisions of this act. Such applicant shall pay to the Secretary of State a fee to be fixed by the Secretary of State covering a reasonable cost of such test. The Secretary of State shall be authorized to issue certificates of approval of such types of headlighting equipment as have been shown by exact scientific and laboratory tests under uniform specifications to conform with the requirements of this act when used in accordance with the instructions in Section 10. The reports of all tests shall be accessible to the public. The Secretary of State shall publish and disseminate a list of approved types of headlighting equipment.

6. For the purpose of preparing specifications and instructions for the headlamp tests, the Secretary of State shall be authorized to establish a board of not less than three experts not commercially interested directly or indirectly in any headlighting control apparatus, who shall serve without pay and who are qualified to make in terms of measurable quantities, an interpretation of the requirements of this act; or he may adopt specifications and instructions prepared and recommended by a recognized engineering society of national scope specializing in the subject of light and illumination. The uniform specifications and instructions so established shall be promulgated by the Secretary of State and shall relate to

(*a*) Tests of headlights on motor vehicles as made in public testing stations provided for in Section 7. This specification shall include a numerical interpretation of the illumination required for discernibility of a person, vehicle or substantial object at distances ahead of the motor vehicle set forth in Sections 1 and 2, and also numerical interpretations of the limits of dangerous glare and dazzle set forth in Section 3.

(*b*) Laboratory tests of headlighting devices for the purpose of determining their acceptability under Section 5. These specifications shall set forth the manner in which the tests are to be made

and the numerical limits imposed on approved devices with reference to the power of the light produced and the limitation of glare to conform to the requirements of Sections 1 and 3.

7. The Secretary of State shall be authorized to license individuals who in his judgment are properly equipped and otherwise qualified to test and adjust the headlamps of motor vehicles for conformity to the law as interpreted by the specifications provided for in subdivision (a) of Section 6.

8. Police officers shall be empowered to issue to such drivers as in their judgment violate any of the provisions of this act, summons requiring the person charged with such violation to appear at a licensed test station as provided for in Section 7, within a term of .... days for a test of the headlamps. The Secretary of State shall authorize such licensees to collect a fee, not to exceed .... dollar , for such services. The licensee shall keep a record of all tests made by him. The license numbers of such motor vehicles and the results of the test shall be reported to the Secretary of State (and to the proper municipal authorities), and the results of the test shall also be reported to the person charged with violation of the act. The results of such tests shall be presumptive evidence in any prosecution for violation of the provisions of this act. If any person so served with summons does not submit to the test as required in this section, the testimony of the police officer serving same shall be presumptive evidence of such violation. A person charged with violation of the act shall have the right to appeal to the Secretary of State from the findings of such tests.

9. The Secretary of State shall be authorized to send inspectors of motor vehicle lamps upon the highways at night for the purpose of verifying by measurement, conformity to the provisions of this act.

10. No headlamp or headlamp control device shall be sold by a dealer that is not accompanied by a printed sheet of instructions describing the device in detail, its method of mounting and adjustment, type and candlepower of lamps to be used and any other adjustments that may be necessary to insure its conformity with the requirements of this act.

11. On and after ...., no type of headlamp equipment shall be sold that has not been officially approved by the Secretary of State.

NOTE: 1. The above regulations relate only to what are known as headlamps, or "headlights," and to "spotlights."

It is assumed that in a complete act sections will be added to cover front lamps other than headlamps, "tail" lamps, side lamps and direction indicating lamps where required, exceptions to conform with municipal regulations, penalties for violation, etc.

2. The aim of the committees has been to set forth clearly the intent of the regulations. It is assumed that the phraseology will be altered where necessary to conform with legal requirements to insure the proper administration and enforcement of the act.

3. It is assumed the title of any other proper administrative official or board may be substituted throughout for that of the Secretary of State, and that the titles of proper municipal authorities will be inserted in Section 8.
4. Referring to Section 7, the desirability of licensing properly qualified garage mechanics is suggested.
5. Referring to Section 8, it is suggested that the fee for a test, made in response to a summons, at a public test station, should not exceed $1.00, and that the test in response to such a summons should be made within a term of two days.
6. Referring to Section 11, it is suggested that the date be fixed at one year from the date this act becomes effective.

ABSTRACT—THE LIGHTING OF COTTON MILLS.*

BY A. L. POWELL.

With the development of higher efficiency illuminants and the wide variety of reflecting material, considerable changes have been brought into play in textile mill illumination methods.

The improved mill constructions with higher ceilings and light colored surroundings have been another factor in this change. The gradual adoption of individual or group drive has, to a great extent, eliminated overhead obstructions in the way of shafting, belting, etc.

General illumination by means of medium size and large lamps with suitable reflecting device is rapidly superseding the old methods of localized or localized general illumination. These changes have been attended by gains in economic operation, improved appearance of a plant and more cheerful working conditions.

Among the points discussed by the speaker in introductory remarks were artificial lighting as an element of production; light and safety effect of good illumination on surroundings and morale; choice of the proper lamp and reflecting equipment; maintenance of installation; color of surroundings; systems of lighting; methods of illumination and color inspection with artificial light. Detailed data accompanied by lantern slides made from night photographs was presented, showing the present practice in lighting modern Cotton Mills. The best methods of lighting the individual processes or machinery, such as bale breakers, pickers, cards, drawing frames, slubbers, spinning frames, warpers, slashers, looms, etc., etc., were described in detail and the lighting requirements were analyzed in each case.

* A paper presented before the New England Section of the Illuminating Engineering Society, Boston, Massachusetts, November 15, 1918. The full text of the talk, with some additional material will be found in a series of articles by the author entitled, "Present Practice in Cotton Mill Lighting." These appeared in the August, September and October, 1918 issues of "Cotton" by W. R. C. Smith Publishing Company, Atlanta, Ga.

TRANSACTIONS
OF THE
Illuminating Engineering Society
PART II -- PAPERS

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SOME EXPERIMENTS ON THE EYE WITH DIFFERENT ILLUMINANTS*—PART II.

BY C. E. FERREE AND G. RAND.

INTRODUCTION.

In the immediately preceding paper it was pointed out that a belief seems to prevail among laymen and not a few medical and technical men that the kerosene flame as a source of light possesses advantages for the eye not had by other illuminants, more particularly the incandescent solids. In that paper results were shown comparative of the effect of the following filament lamps on the power of the eye to sustain clear and comfortable seeing: the carbon lamp (metallized filament), the Mazda type B lamp, the Mazda type C lamp, and the Mazda type C-2 lamp. In the work of the present paper the comparative testing was continued. Welsbach gas mantles of different proportions of ceria and thoria were used and the results obtained were again, for the sake of carrying out the original plan, compared with those gotten with the kerosene flame.

CONDITIONS TESTED.

The illuminants tested in this series were the kerosene flame; two shortened "Ramie" Welsbach mantles, single mesh weave—one with 0.7 per cent. ceria and 99.3 per cent. thoria, the other with 2 per cent. ceria and 98 per cent. thoria; and seven "Ramie" Welsbach mantles, single mesh weave, of the size known as Junior mantles, having a 0.25 per cent. ceria and 99.75 per cent. thoria, 0.5 per cent. ceria and 99.5 per cent. thoria, 0.7 per cent. ceria and 99.3 per cent. thoria, 1 per cent. ceria and 99 per cent. thoria, 2 per cent. ceria and 98 per cent. thoria, 3 per cent. ceria and 97 per cent. thoria, 5 per cent. ceria and 95 per cent. thoria.

* Paper presented before the New York Section of the Illuminating Engineering Society, New York, N. Y., March 2[illegible] [illegible]

Part I printed in TRANSACTIONS, I. E. S., Vol. XIII, No. 1, p. 50.

For the sake of comparison with the kerosene flame, it might have been desirable to have conducted the tests with the gas illuminants equal to it photometrically, or approximately so, as well as with an equally illuminated reading page and test object. This was, of course, impracticable with the Junior mantles. To serve as a check on this factor, however, two of the mantles were shortened. They were cut to a length of 1.5 in. in order to make them as nearly as possible of the same candlepower as the kerosene flame burning at a height of 3 in. (Lusterlite kerosene, horizontal candlepower 15.8). Since the light from the top of the mantle differs in color value from that emitted from the middle and lower parts, this shortening of the mantle caused a change in the color value of the total flux of light. The effect of this change on the coloration of the reading page was quite noticeable, for example, in the mantle having 0.7 per cent. ceria and 99.3 per cent. thoria. Steadiness of pressure and freedom from flicker in the light emitted were secured by means of a Baylis low pressure automatic governor weighted to give 2.5 in. water pressure. A further means of regulating the flow of gas and making small changes of pressure, if needed, was provided by inserting a gasoline needle-valve directly beneath the Bunsen burner.

The same standard, one burner student lamp fixture, fitted with a gas burner, a dummy chimney, etc., was used as was employed in the preceding experiments. We were led, it will be remembered, to choose this particular type of unit in part because the belief in the superiority of the kerosene flame for the eye is, in the minds of those we have questioned, associated largely with the lighting effects given by the student lamp; and in part because this lamp is well adapted to give the control of conditions under which we wished the first series of tests on the effect of color value of light to be made. Care was taken to adjust the position of the shade so that it sustained in each case approximately the same relation to the mantle. The bottom of the shade was, for example, in all cases 25 cm. below the center of the luminous source. The lamp was placed behind and to the left of the observer in the position that was judged by several observers to give the conditions most favorable for reading. This position may be specified roughly as follows. The angle with the median

plane of the observer made by a plane passing vertically through the center of the unit was approximately 21°, and the line in the latter plane connecting the bottom of the shade with the center of the reading page formed an angle of approximately 38.5° with the horizontal plane passing through the center of the reading page. The reading page was supported by a rack fastened to the upright to which was attached the mouth-board used by the observer in taking the 3-minute record before and after work. This rack was inclined at an angle of approximately 30° with the vertical. To insure that the same amount of light fell on the reading page in each case, the brightness of the page was measured before and after work by means of a Sharp-Millar illuminometer with the test plate removed, and calibrated to give readings directly in candlepower per square inch. The changes needed to give equality of illumination on the reading page were made by changing the distance of the lamp from the page. These changes in case of either the full length mantles or the shortened mantles were small. The changes required, however, to equalize the full length mantles with the shortened mantles were greater. This meant for the full length mantles a slightly greater general illumination of the observer's field of view and a slightly different brightness of surroundings. That is, these mantles of higher candlepower placed at a greater distance from the reading page illuminated a larger field about the page than the mantles of lower candlepower. In making the changes of distance care was taken to keep the angle at which the light fell on the page in all cases the same.

Owing to the angle of direction of the light and the distance of the lamp the test object had to be illuminated from a separate source. For this a Mazda type B lamp and an Ivanhoe-Regent steel reflector of the intensive type, aluminum lined, were used, placed in front and to one side of the test object at the distance and angle needed to give the required illumination. In order that the test object alone should be illuminated and not the surrounding wall, objects, etc., the opening of the reflector was covered and an oblong aperture was cut of the size and shape needed to give the desired cross-section of light. The position of this aperture in the opening of the reflector was chosen with reference to giving the greatest possible evenness of illumination of the

test object. That is, the light was not taken directly from the lamp but from the most favorable part of the inner surface of the reflector. The test object was made to match the reading page both in brightness and color value. The match in color value was secured by means of thin gelatine filters covering all or a part of the aperture. If only a part of the aperture was covered, the filter was used as a diaphragm with an opening similar in shape to the original aperture. There was, for example, enough difference in the color value of the different illuminants and the Mazda lamp that without this match an after-effect was given on the test object distinctly different in color from the reading page. This would have necessitated that the final 3-minute record be taken in part at least with a test object having a coloration complementary to the reading page, which would not have been compatible with the purpose of the test. Before beginning each test of the series, the eye was allowed the customary adaptation period without work under the illumination to be tested. The choice of the length of adaptation period was empirical based on a series of acuity tests, the object being to determine a period the prolongation of which gave no further change in acuity.

As was the case in the former experiments an opaque shade of the same size and design and with a neutral lining was substituted for the green shade with which the student lamp is usually provided. That is, it was considered advisable to conduct the test with the color value proper to the illuminant, unmodified by the light which filtered through the shade even though the position of the lamp was such that a very small part of the light which fell on the reading page was of this origin.

The reading page illuminated by the different light sources had the following color values: kerosene flame, orange yellow; Welsbach mantle 3 per cent. ceria 97 per cent. thoria, unsaturated pale yellow; Welsbach mantle 5 per cent. ceria 95 per cent. thoria, reddish yellow more saturated; Welsbach mantle 2 per cent. ceria 98 per cent. thoria, unsaturated yellow with a trace of green; Welsbach mantle 1 per cent. ceria 99 per cent. thoria, unsaturated yellow with more green; Welsbach mantle 0.7 per cent. ceria 99.3 per cent. thoria, unsaturated yellowish green; Welsbach mantle 0.5 per cent. ceria 99.5 per cent. thoria, greenish with perhaps a trace of yellow; Welsbach mantle 0.25 per cent. ceria

99.75 per cent. thoria, bluish green more saturated. These estimates of color value are based in part on a direct comparison with color standards, in part on the filters that had to be used to make the color match between the test object illuminated by the Mazda type B lamp and the reading page lighted by the illuminant to be tested. We have not as yet made a standard colorimetric or spectrophotometric determination.

The tests were conducted in a room 16 ft. 6 in. (5.03 m.) long, 11 ft. 9 in. (3.58 m.) wide, and 9 ft. 6 in. (2.98 m.) high. A photograph of the room with an observer, lamp and recording apparatus in position were shown in Fig. 2 of Part I of this subject (TRANS. I. E. S., Vol. 13, No. 1, p. 54). The recording apparatus and the fixtures for lighting the test object are, it will be noted, screened from the observer's view.

For a detailed statement of the care that has been exercised in the selection and use of observers and the precautions that have been used to secure reproducibility of results and to check up the influence of variable extraneous factors by means of a careful determination of the mean error of the observations both in the 3-minute records and in the 3-hour tests under the several conditions, see pp. 7-8 of the immediately preceding paper (TRANS., 1918, XIII; also TRANS., 1915, X, pp. 1122-1130) and various places in other preceding papers.

The results for the effect on the eye are given in Table I. The values given in this table are averaged in each case from the results of a number of 3-hour tests. In order to show the reproducibility of the results obtained and to determine whether the variations produced by the changes in lighting effects are safely in excess of the variations in the test itself, subject to all of the factors which may influence it, the mean variations from the average result have been computed in each case. The value of these in per cent. is given in columns 9 and 10 in Table I. This value has been estimated in two ways. In column 10 it is based on the result sought, namely, the mean value of the drop in ratio of time seen clear to time seen blurred. Computed in this way the results indicate whether or not each individual determination has been made with an acceptable degree of precision as compared with other work of its class. In column 9 it is based on 3.5, the value of the ratio time clear to time blurred which has been

chosen empirically as the standard of performance of the eye in the 3-minute record before work. Computed in this way the results appear in a form from which it can readily be determined whether or not the work has been done with a degree of precision which is acceptable for the comparative work which is the special purpose of these experiments. That is, to be acceptable

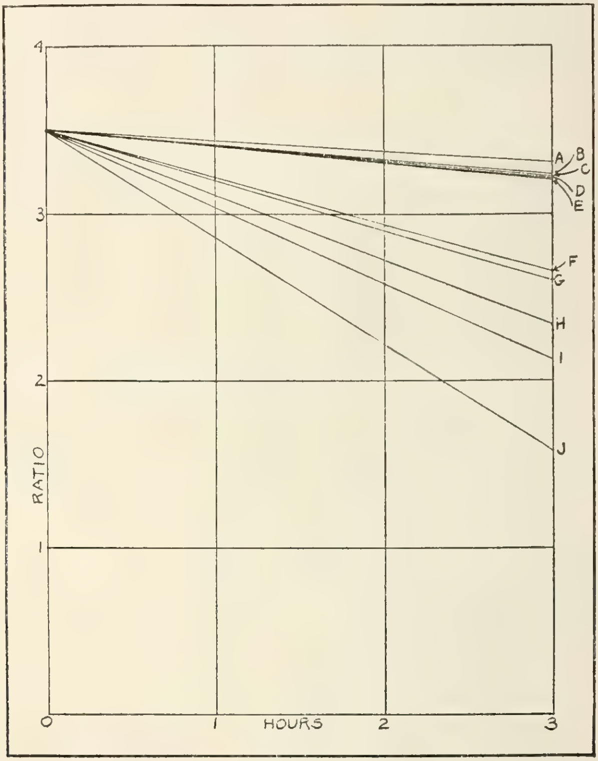


Fig. 1.—Showing the tendency of the different illuminants to cause loss of visual efficiency or power to sustain clear seeing. Ratio time clear to time blurred plotted against length of test period.

(A)—3 per cent. ceria—97 per cent thoria.
(B)—5 per cent. ceria—95 per cent. thoria.
(C)—2 per cent. ceria—98 per cent. thoria.
(D)—Kerosene flame.
(E)—2 per cent. ceria—98 per cent. thoria (shortened).
(F)—1 per cent. ceria—99 per cent. thoria.
(G)—0.7 per cent. ceria—99.3 per cent. thoria (shortened).
(H)—0.7 per cent. ceria—99.3 per cent. thoria.
(I)—0.5 per cent. ceria—99.5 per cent. thoria.
(J)—0.25 per cent. ceria—99.75 per cent. thoria.

in this regard, the variations of the drop in ratio caused by changing the conditions to be tested, must in each case be safely in excess of the mean variation. To make this comparison convenient, the drop in ratio and the mean variation have both been estimated on the same base, 3.5.

In Fig. 1 a graphic representation is made of the results in Table I. In constructing this chart the total length of the test period is plotted along the abscissa and the ratio of the time the test object is seen clear to the time it is seen blurred is plotted along the ordinate. Each one of the large squares along the abscissa represents one hour of the test period; and along the ordinate, an integer of the ratio. In Fig. 2 loss of efficiency or

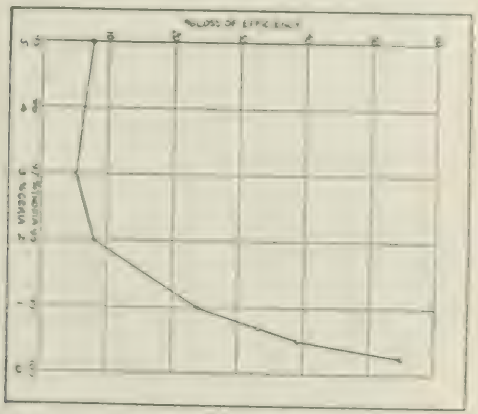


Fig. 2.—Showing the tendency of the different illuminants to cause loss of efficiency or power to sustain clear seeing. Loss of efficiency in per cent. is plotted against composition of mantle.

power to sustain clear seeing expressed in per cent. is plotted against composition of mantle. In this chart and in Fig. 3 the results for the shortened mantles are not represented.

As formerly the work was concluded by determining for the different illuminants used the relative tendencies to produce ocular discomfort with the eye at work. A description of how the determinations were made and a discussion of the method

that was used has been given in previous papers. The results are given in Table II. In this table are given also for the sake of comparison results expressing the tendency of each type of illuminant to cause loss of ability to sustain clear seeing. A graphic representation of the results of this table are given in Fig. 3. Here as in Fig. 2 the results of the test are plotted against composition of mantle.

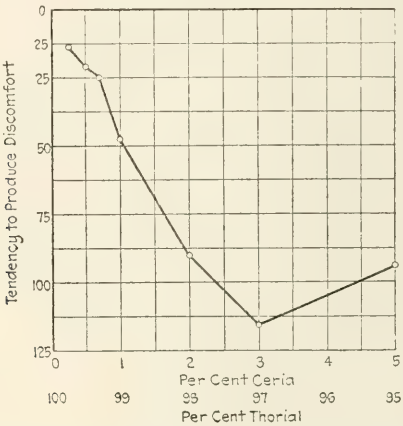


Fig. 3.—Showing the tendency of the different illuminants to produce ocular discomfort. Tendency to produce ocular discomfort is plotted against composition of mantle.

TABLE I.

Showing the tendency of the different illuminants to cause loss of visual efficiency, or power to sustain clear seeing.

Type of illuminant	Dominant color	Brightness (cp per sq in.)		Time	Working distance (c.m.)	Total time clear (Sec.)	Total time blurred (Sec.)	Total time clear ÷ total time blurred	Ratios reduced to common standard	Loss of efficiency expressed in percentage change of ratio	Mean variation (per cent.)	
		Test object	Reading page								Based on 3.5	Based on result sought (drop in ratio)
Welsbach mantle, 3 % ceria, 97 % thoria	Unsaturated, yellow	0.003168	0.003344	9 A.M. 12 M.	62 62	140.0 138.25	40.0 41.75	3.50 3.31	3.50 3.31	5.43	0.256	1.26
Welsbach mantle, 5 % ceria, 95 % thoria	Reddish yellow more saturated.	0.003168	0.003344	9 A.M. 12 M.	60 60	140.0 137.50	40.0 42.50	3.50 3.235	3.50 3.235	7.57	0.22[illegible]	[illegible]
Welsbach mantle, 2 % ceria, 98 % thoria	Unsaturated yellow, with trace of green	0.003168	0.003344	9 A.M. 12 M.	60 60	144.0 141.50	36.0 38.50	4.00 3.67	3.50 3.21	8.2[illegible]	[illegible]	4.[illegible]
Kerosene flame	Orange yellow	0.003168	0.003344	9 A.M. 12 M.	60 60	139.17 136.33	40.83 43.67	3.408 3.122	3.50 3.2[illegible]	8.[illegible]	0.3[illegible]	[illegible]
Welsbach mantle 2 % ceria, 98 % thoria (shortened)	Unsaturated yellow, with trace of green.	0.003168	0.003344	9 A.M. 12 M.	60 60	142.40 139.70	37.60 40.30	3.787 3.466	3.50 3.2033	8.48	[illegible]	4.[illegible]
Welsbach mantle, 1 % ceria, 99 % thoria	Unsaturated yellow, with more green.	0.003168	0.003344	9 A.M. 12 M.	60 60	141.0 132.0	39.0 48.0	3.62 2.75	3.50 2.[illegible]	24.[illegible]	[illegible]	[illegible]
Welsbach mantle 0.75 % ceria, 99.25 % thoria (shortened)	Unsaturated yellowish green	0.003168	0.003344	9 A.M. 12 M.	60 60	139.33 129.33	40.67 50.67	3.426 2.552	3.50 2.60[illegible]	25.51	[illegible]	[illegible]
Welsbach mantle, 0.70 % ceria, 99.3 % thoria	Unsaturated yellowish green with more green	0.003168	0.003344	9 A.M. 12 M.	60 60	139.50 125.50	40.50 54.50	3.444 2.30[illegible]	3.50 2.34	33.14	[illegible]	[illegible]
Welsbach mantle 0.[illegible] % ceria, 99.[illegible] % thoria	Greenish (perhaps trace of yellow)	0.003168	0.003344	9 A.M. 12 M.	60 60	142.0 125.0	38.0 55.0	3.737 2.273	3.50 2.13	39.14	[illegible]	[illegible]
Welsbach mantle 0.25 % ceria, 99.75 % thoria	Bluish green, more saturated	0.003168	0.003344	9 A.M. 12 M.	60 60	142.35 113.50	37.65 66.50	3.781 1.707	3.50 1.58	54.8[illegible]	[illegible]	1.25

TABLE II.

Showing a comparison of the tendency of the different illuminants to cause loss of visual efficiency and to produce ocular discomfort. The tendency to produce discomfort is estimated by the time required for just noticeable discomfort to be set up.

Type of illuminant.	Dominant color.	Brightness (Cp. per sq. in.) reading page	Per cent. loss of efficiency	Mean variation (per cent.)	Time threshold of discomfort in seconds (reading)	Mean variation (per cent.)	Change produced by changing type of illuminant (per cent.)
Welsbach mantle, 3 % ceria, 97 % thoria.	Unsaturated yellow.	0.003344	5.43	0.286	116.0	1.30	—
Welsbach mantle, 5 % ceria, 95 % thoria.	Reddish-yellow, more saturated.	0.003344	7.57	0.2257	94.0	1.07	18.97
Welsbach mantle, 2 % ceria, 98 % thoria.	Unsaturated yellow, with trace of green.	0.003344	8.29	0.390	90.0	0.83	4.26
Kerosene flame.	Orange-yellow.	0.003344	8.39	0.323	90.0	0.55	0.0
Welsbach mantle, 2 % ceria, 98 % thoria (shortened.)	Unsaturated yellow, with trace of green.	0.003344	8.48	0.3828	90.0	0.55	0.0
Welsbach mantle, 1 % ceria, 99 % thoria.	Unsaturated yellow with more green.	0.003344	24.0	0.571	48.0	1.04	46.67
Welsbach mantle, 0.70 % ceria, 99.3 % thoria (shortened.)	Unsaturated yellowish-green.	0.003344	25.51	0.250	34.0	2.94	29.17
Welsbach mantle, 0.70 % ceria, 99.3 % thoria.	Unsaturated yellowish-green, with more green.	0.003344	33.14	0.860	25.0	2.00	26.47
Welsbach mantle, 0.50 % ceria, 99.5 % thoria.	Greenish (perhaps trace of yellow).	0.003344	39.14	0.857	21.0	3.50	16.00
Welsbach mantle, 0.25 % ceria, 99.75 % thoria.	Bluish-green.	0.003344	54.86	0.690	14.0	2.36	33.33

DISCUSSION

Alexander Duane (Communicated): Speaking from the viewpoint neither of the psychologist nor of the engineer, but of the oculist, I should say that Professor Ferree in his exhibits shown here to-night has given an excellent clinical proof of his thesis. As I have looked from a distance of some 10 ft. at the pages illuminated by the different types of mantle, it was very soon apparent that for my eyes the light of mantle *I* would in a short time become intolerable, while *A* or *C* would afford comfortable reading. I seemed to have no difficulty at all in making the choice. This impression was confirmed by a second observation, made at close range. To those who have objected that Dr. Ferree's methods were ultra-scientific and did not lend themselves to practical demonstration by those who were not professed psychologists, and to those also who have suggested that the results obtained might be based on some personal idiosyncrasy of the observer and could not therefore be claimed as representative, I would suggest the use of a simple apparatus like that here shown, which could be tested out—I should think convincingly—upon a number of persons in a comparatively short time—the persons tested noting the sensations produced by the several types of illuminated page and indicating their preferences.

C. E. Ferree (In reply): It affords Dr. Rand and myself no little gratification to have an opinion based on direct observation from one of the wide experience of Dr. Duane in eye testing, research and clinic work on the eye. In his study of the eye both elements have been combined—the laboratory procedure and the general clinical and observational aspects. He should be qualified to look at all sides of the question with a more balanced judgment perhaps than is possible for the laboratory worker or the engineer. Moreover, few have researched more extensively than Dr. Duane on eye functions of the type involved in this work and no one perhaps is more competent to give an expert opinion on the technical merits of work in this and allied fields.

Wm. J. Serrill (Communicated): Regarding the paper by Dr. Ferree and Miss Rand, I may say that these experiments are of decided interest insofar as they show that continued read-

ing by an artificial light containing a large proportion of yellow rays is better for the eye than with a light containing greenish or yellowish rays. The results thus indicated are of so important a nature that I think they should be verified by further experiment, and I hope that Dr. Ferree and Miss Rand will see their way clear to continuing these investigations so that their results can be based on the average of a much greater number of tests and conducted by a much greater number of individuals.

C. E. FERREE (In reply): I agree with Mr. Serrill that it is desirable to have results for a greater number of observers. However, the small value of the mean variation, as shown by the tables, indicates I think that a greater number of tests per individual is not needed. It has been our practice from the beginning to average the results of six or more (depending on the size of the mean variation) 3-hour tests for each observer for each lighting condition. The present tests covered a period of more than 120 days.

The results do not by any means show that light of a more saturated yellow is better for the eye than light of a less saturated yellow, as is implied in Mr. Serrill's statements. What they do show with regard to the mantles *A, C,* and *F,* if conclusions are to be drawn at this time, is that an unsaturated clear yellow gives a better result than unsaturated yellow tinged with green. It will be noted too that the differences in result for these mantles, to which Mr. Serrill's statement obviously refers, are small and not conspicuously significant. The larger and more significant differences appear with the mantles giving a larger proportion of green and blue-green. For the sake of confirming this result it is our purpose to extend the work to include the testing of the effect of these variations in color obtained in other ways.

JAMES R. CRAVATH (Communicated): The results in this and the previous paper covering eye fatigue tests with different colors of illuminants, indicate less fatigue with illuminants giving a yellowish light than with those giving white or greenish light. Most people have an inherent preference for yellowish rather than greenish light for illumination purposes. Whether this inherent preference is due to the greater eye fatigue with the

greenish light is unnecessary for us to speculate. It would be interesting to carry this investigation still further toward the green end of the spectrum and determine whether with a nearly monochromatic illuminant, such as the mercury vapor lamp, the eye fatigue test would still show unfavorably to the greenish color. The two investigations carried on by Dr. Louis Bell and Dr. M. Luckiesh indicated better visual acuity with a light nearly monochromatic like the mercury vapor, than with others. Whether this better visual acuity would outweigh the apparent preference of the eye for yellowish illuminants brought out in these papers, would be an interesting study.

C. E. Ferree (In reply): I would disagree with Mr. Cravath that any results which we have as yet obtained indicate that yellow light is better for the eye than white light. With such retinas and powers of discrimination as are possessed in our laboratory we would judge that we have not in this or the former study worked with a light which is not considerably more than just noticeably colored. For example, we do not consider the light given by the mantles *H* and *I* white. While these mantles do not give colors so saturated as are given by *A*, *B* and *C*, the deviation from white is in a different direction in the hue scale—a fact which should by no means be ignored. In short, if one were willing to draw conclusions with regard to the effect of color value at this stage of the investigation, he would be tempted to say that in case of a given color the power to sustain clear and comfortable seeing decreases with the saturation of the color; but that a displacement from white towards the short wave-length end of the spectrum affects the eye more than a similar displacement towards the long wave-lengths. In all discussions as to the relative merits of *near* and *would-be* white lights, artificial daylights, etc., it should be kept in mind that our best results thus far have been obtained with *daylight*.

Any results obtained with mixed colored lights should by no means be construed without further investigation as applying to lights more nearly of spectrum purity. We have already been provided by the manufacturers with a mercury vapor lamp for test purposes. A fair comparison, however, may not be possible because of the difficulty of getting a strictly com-

parable installation. We should like also to add to the series the Neon and carbon dioxide and nitrogen tubes, but have thus far not been able to secure them for test purposes.

CAPT. H. LOGAN: The conditions enumerated in the series of tests under consideration, provide that the different sources of illumination were all reduced to the same candlepower as they appeared on the page read.

Therefore, the only difference in the kinds of illumination is their color or tint on the paper upon which the individual tested was looking. The inference therefore suggests itself that the difference in effect upon the person tested was due to this difference in color.

The tests show that when an orange-yellow was used (kerosene flame) fatigue was experienced much sooner than when an illuminant giving an unsaturated yellow was used, and there seems to be a remarkable coincidence in this fact by the employment of both the Mazda type lamps and the Welsbach mantles, for in both instances almost identical results are obtained when the reddish admixture is used, and there is a considerable jump in the fatigue period when the blue type of illumination is employed.

Is it, therefore, possible that in the individual selected as a type, the fatigue periods were largely influenced by the color of the illuminated page, and was the individual selected as a type, selected with the thought in mind of this color influence?

Would the individual selected, therefore, be a fair guide for other groups of individuals who might be differently affected by the same color or by other colors?

Since, from a description of the experiments, the only difference was that of the color of the light produced on the reading page, has this point received the consideration to which it is obviously entitled?

C. E. FERREE (In reply): The characteristics of response of the eyes for which these results are given have been very widely investigated. They have been chosen especially for their normality and practiced precision of behavior and have been used in

these experiments under conditions of control based on a very unusual and widely tested knowledge of the factors which influence their steadiness of response. Data on their characteristics of response may be found in more than forty articles. See, for example, (Ferree and Rand) "The Selectiveness of the Achromatic Response of the Eye to Wave Length and Its Change with Change of Intensity of Light," *Studies in Psychology*, Titchener Commemorative Volume, Brandow Printing Co., Albany, N. Y., 1917; and also *Psychological Review*, 1919, XXVI, pp. 16-42. I doubt whether there is a pair of eyes in existence whose characteristics of response, retinal and muscular, have been so widely and minutely investigated and recorded. Moreover, in the preceding six years of work on the effect of different types of reflector we have found the results of this observer to be typical of the group of observers used; also the general trend of the results obtained in the present experiments has been confirmed by a statement of preference, so far as the judgment and feeling of working comfortably and efficiently is concerned, by several observers, selected at random, who have worked for us without taking the tests under lights of green and yellow coloration.

C. H. Sharp: As I understand the conclusion which Prof. Ferree draws from his experiments, it is that there is a decreased efficiency of the eye or power to sustain clear seeing of roughly 50 per cent. in working for three hours under the light of a white mantle as compared with a yellow kerosene flame or its equivalent. There are two questions which occur at once regarding this conclusion. First, is the method a valid one for the purpose of establishing it? Second, is the effect which is found attributable only to color difference in the illuminants? As regards the first question, without presuming in any way to criticise the method which Prof. Ferree has used in this and numerous other researches, it would seem that if an effect as large as the one here indicated really exists, it ought to be possible to demonstrate it by simple experiments of a kind the validity of which would be recognized even by those of us who are not versed in the experimental methods of the professional psychologist.

To make the suggestion more concrete, suppose a test room were arranged so as to be illuminated to an equal degree and in

a similar manner by a yellow or by a white illuminant. For example, let a semi-indirect bowl be used in which either illuminant could be placed. Let the total flux of light and its distribution be the same in both cases. Let the observer read continuously an interesting book printed in moderately fine and bad type so that there can be no doubt that real ocular fatigue will ensue. At the outset let him be subjected to a test to show what might be called his normal rate of visual apperception. This part of the suggestion I offer with extreme diffidence, for it encroaches on the field of the professional psychologist, and I may from his point of view be putting forth a proposition which is quite untenable. But with due reservations of this kind suppose the observer is given the telephone directly and is asked to read as many of the badly printed and relatively illegible figures which it contains as he can in a given space of time. A recorder will note the numbers as he gives them and by comparison later will determine the number of errors which he makes. The total number of errors combined with the total number read and weighted according to some method which Prof. Ferree would be better able to suggest than I am, might be taken as a measure of the condition of his eyes at the time. This test should be repeated after having read the book for a sufficient period of time to make sure that the eyes have really been fatigued. By making tests of this kind with the yellow and with the white light and repeating them a sufficient number of times to make sure that fortuitous conditions are eliminated, it surely ought to be possible to show up quantitatively and with a good deal of obvious probability any difference of the order of magnitude of this one which the present paper points out.

The suggestion above has at least the merit of answering the second question proposed above, for if the flux, distribution and intensity are the same, and only the color has been changed, and if a sufficient number of experiments are made to eliminate the accidental variations, the only outstanding reason for any difference would be the color of the light, and so the proposition would be established as far as that is concerned.

I wish to put on record my admiration for the ingenuity displayed by Prof. Ferree in developing his method of eye testing and for the persistency with which he has carried out his experi-

ments. He will do a great service to the science and art of illuminating engineering if he will only take up, not necessarily the above, but some simple method which will appeal to the average man whereby the probable validity of his own method will be either substantiated or disproved. Those of us who are not psychologists have no means of forming an independent judgment on his method and I think that while we are all very much interested in it and in the conclusions which he is drawing from his experiments conducted according to it, yet we cannot under the circumstances fail to raise such questions as are indicated in the beginning of this discussion. If he will once for all answer the question as to the general validity of his method, we can see that his experimental results will be of the greatest practical value in illuminating engineering, and I wish to put in a plea to him to take some such action.

C. E. Ferree (In reply): (1) I think perhaps that Dr. Sharp misunderstands the purpose of the tests and therefore misconstrues the results. The tests are hygiene, not specific performance tests. They are designed to rate lighting and conditions with regard to their tendency to cause ocular fatigue and discomfort, but the results are *quantitative* only in terms of the task that is set for the eye by the tests. If, for example, there is found a difference of 50 per cent. before and after work under a given lighting condition in the ability of the eye to meet the standard imposed by the test, it by no means indicates that there would be a 50 per cent. difference in the observer's speed and accuracy of reading, drafting, doing the work of a machinist, etc. The value of a factor which would be needed to convert the results of the tests into loss of power to do any particular type of work would depend first upon the importance of a high degree of clearness of vision to that work and secondly upon how much the particular degree that is needed is disturbed by fatigue conditions. Perhaps the engineers feel that specific performance tests would be more applicable to their needs. If so, a different test would be required for each type of work for which the lighting is installed. Moreover, unless the test is to consume weeks or months, some means must be employed of increasing the normal severity of the task, else the test will not have the

sensitivity which is needed to indicate in the short time of application allowed by the test what is to be expected in the longer periods for which the light is to be used. The need of a converting factor would thus by no means be avoided. We have confined ourselves to a general test to indicate in what direction the danger lies in lighting in its relation to the eye. Just what value our data and conclusions should have to the man whose interest is primarily in the conservation of vision, to the factory manager who perhaps knows more about his machines than about the men who run them, to the employment managers and efficiency experts who look at the efficiency of the employee as well as of the machines they operate, each is left entirely free to judge for himself.

(2) Dr. Sharp suggests confirmatory results obtained by some simple means which are familiar to the engineer. If a physicist, in presenting a paper before some medical society, shows the energy curve of a visible spectrum as measured by a thermopile, the medical man could not expect the physicist to show some difference in the heating power with the clinic thermometer. I do not think this analogy is as exaggerated as it may appear to the engineer. We who are doing the work of testing are asked to rank or grade lights in their terms of tendency to produce deleterious effects in the course of weeks, months, or even years on the basis of the difference in the amount of effect that is produced in the short period that can be feasibly used in the work of testing. The simple tests which are familiar to the engineer will not, I fear, pick up these differences any more than the clinic thermometer will show a difference in the heating power of the red and violet ends of the spectrum. It was in fact just because the simpler and more familiar means had failed that the problem was laid before a special committee by the American Medical Association eight years ago. The stock laboratory tests and the tests with which the practicing ophthalmologist is familiar would not show an effect for so short a time of exposure sufficiently greater than the mean error of the test to serve as a safe basis of comparison between the different lighting conditions. I do not mean to say that the effect that comes from long periods cannot be detected by these tests and is therefore negligible. It is only the effects which accrue in the short periods feasible to

use in such test series as we are conducting that demand a more sensitive test method. In substance, when we added the time element to the conventional acuity test, we did in effect, just what is done for an insensitive physical recording instrument when it is used in connection with an amplifier, and the amplifier was added that we might be able to indicate in the short periods feasible for testing the direction in which the danger lies in lighting as applied to the working life. In doing this we were not only justified, I believe, but wholly in line with sound experimental procedure.

We feel that clinic tests are serviceable only when the damage has been done and the eye has been rendered subnormal to a degree which cannot be overcome even momentarily by the spur of the will.

Dr. Sharp insists upon confirmatory evidence of the validity of the tests as applied to the practical problem of lighting. The following points may be of service in this connection. (*a*) A number of observers have worked, without themselves taking the tests, under the lighting conditions rated as good and bad and have without exception expressed their preference for the former so far as their judgment and feeling of working comfortably and efficiently was concerned. (*b*) In the work with the different types of reflectors covering a period of six years and including the testing of more than fifty different lighting situations, the results of the tests show a truly remarkable correlation with the variations of the maximum brilliancies in the field of view. (*c*) A very close correlation obtained between the results for loss in power to sustain clear seeing and the tendency to produce ocular discomfort. In fact, in some cases the curves for the two sets of results almost superimpose. (*d*) Since evidence of a general rather than a test nature is wanted it may not be out of place to note here also an experience which we had with several observers with light of saturated colors before we began the work on the different illuminants. We had planned a series of experiments on composition and color value of light, using 100-watt Mazda type B lamps dipped in red, yellow, green and blue dyes, indirect installation. The coating on the lamps was sufficiently dense to give walls, ceiling, reading page, etc., of strongly saturated colors. After an hour of work under the

green light the eyes had suffered severely. The sclera had become injected or bloodshot and so much discomfort was experienced that the plan of using saturated colors was for the time being abandoned. So trying was the experience that several hours had elapsed before the eyes had regained their normal appearance and comfort. The red at a later trial was worse than the yellow, but apparently not so bad as the green. The blue has not yet been tried.

The test proposed by Dr. Sharp is almost identical with that used by Richtmyer and Howes in 1916. The feasibility and applicability of this test for the problem in hand was discussed by us in detail at that time. (TRANSACTIONS, 1916, XI, pp. 106-111.) Time does not permit us to repeat this discussion, but it may be said that the literature on the subject of rate of reading is extensive. It would seem that a very low correlation, if any, obtains between the various factors which influence rate of reading and visual acuity.

We had already planned a confirmatory test, however, which will, I believe, embody the essential ocular functions of the test proposed by Dr. Sharp and exclude the objectionable and troublesome extraocular factors, namely, a determination of the speed and accuracy of adjusting the eye for clear seeing at different distances before and after a period of work under the lighting conditions to be tested. The test method and apparatus were devised by us originally in the interests of aviation and were taken to France last August for the purpose of checking up the "tardy ace" in the process of growing stale. We had conceived that the two ocular functions that should be the most affected by fatigue, temporary and cumulative, are power to sustain clear seeing and the speed and accuracy of making the muscular adjustments that are needed for clear seeing. That is, when the eye grows stale or unfit from any cause whatsoever it acquires a very marked lag in its processes, particularly in its muscular functions, and loses rapidly in its power to endure or sustain its normal power of performance. This confirmatory test has too the very great advantage of a mechanical process of recording the speed of adjustment and an objective check on the accuracy of the acuity judgment, features which we have not been able to add to the test which we are now using.

(3) Dr. Sharp raises the question whether the difference in the results obtained are due only to differences in color value. We are not yet ready to say to what they are due. Our conspicuous variables are composition of light (a physical variable) and color value (a sensation variable). The two variables are of course not synonymous nor do they always go hand in hand. For example, white light, so far as sensation is concerned, may be produced in any of the following ways: (a) by combining complementary spectrum bands, (b) by combining larger groups of complementary wave-lengths, (c) by combining all of the wave lengths in proportions balanced for the eye, and (d) by raising to very high intensities lights of any composition. Further lights of different compositions may be sensed as of the same color-hue and saturation. Would white lights of different compositions have the same effect on the power of the eye to sustain clear and comfortable seeing? Similarly would the eye stand up as well under colored lights of the same hue and saturation, but of different compositions? I would point out that daylight, in reaction to which roughly speaking the human eye has developed, is what might be termed a full spectrum light. Would the eye sustain its functional powers as well and as comfortably under every light which matches it in color value even though synthesized from complementary spectrum bands or larger groups of complementary wave-lengths? I believe that it is safe to conclude that they would not be of equal service for color matching, nor is it reasonable to suppose that they would be of equal service for the varied purposes of seeing. The same, I think, might be said as well in general of mixed colored lights matching in hue and saturation, but differing in composition.

We have dealt in these experiments with a series of Welsbach mantles furnished by the Welsbach Company for the purpose, with graded proportions of ceria and thoria and a selectivity of radiation varying with the proportions of ceria—the smaller proportions giving a light with its dominant color somewhere in the greenish-yellows and the blue-greens, and the larger proportions a light with its dominant color in the yellows and reddish yellows. The color values obtained are due to the combination of these two substances in different proportions. If a decision is wanted as to the relative effect of color value and composition

of light the results should be correlated with both of these variables. Since we are not prepared at this time to give a distribution curve for each of these mantles, we have preferred to plot the results against composition of mantle, leaving the decision as to factors an open question. I may say that the late Mr. Pierce attempted to make a correlation of the results of this and the former paper with composition of light, but was unable to carry it far enough to arrive at a satisfactory conclusion.

Howard Lyon: While as a layman I am probably not able to pass judgment on the scientific procedure involved in these tests, still there are points on which I would much like further information.

The observers in these experiments experienced a period of clear seeing of a test object and then a period of blurring or indistinct seeing. What marks the termination of the period of blurring? If the period of blurring is again followed by clear seeing, one is lead to doubt whether this phenomenon would be common to observers in general.

It is generally believed to be true that persistent attention in an effort to identify an object in dim light results in increasing incapacity for seeing. The return of seeing ability comes by temporarily relaxing any effort at attention. Why might not the fatigue caused by different sorts of light be measured directly by the relative time periods of clear seeing?

The numerical results in the form of ratios that are used to express the measure of fatigue are about equal for two lights of equal intensity, namely, that from a type C Mazda lamp and a Welsbach mantle with 3 per cent. ceria. Are not these lights sufficiently different in color to lead one to expect a difference in fatigue effect as this fatigue is supposed to be related to lights varying in color, but identical in intensity of illumination?

It is a fact that a very large proportion of the users of Welsbach mantles object to the light from mantles containing much over 1¼ per cent. ceria. It is doubtful whether mantles containing 3 per cent. ceria could be sold at all. Why is the light, which by these tests produces the least loss of efficiency, not acceptable? Must workers and readers be persuaded and trained to use light of a color giving least fatigue?

C. E. Ferree (In reply). If Dr. Lyon will read the first two articles published by us in 1913 and 1915 and our appended notes (Transactions, 1915, 10, pp. 1124-1127), he will find his first question answered at length. I think Dr. Lyon's trouble has been that he worked with the test object too near the eye in proportion to its size. In other words, it was not near enough to the threshold of acuity for the fluctuations to take place to a degree that was noticeable. If Dr. Lyon worked with supra-threshold conditions I do not wonder that he has asked the foregoing questions. If, however, he will follow directions and work with the eye at or near its maximum resolving power, namely, at or near the threshold of acuity, I am sure that he will get the phenomenon. As our Chairman, Mr. Millar, whose autographed record made in our laboratory is in our possession, has testified, "It is very clear that the phenomenon takes place." In fact we have never yet found an eye for which it does not take place when directions are followed.

If greatly supra-threshold values are used it may be that the suggestion made by Dr. Lyon in his third paragraph could be worked out feasibly for test purposes. I doubt it, however, because I fear that the sensory criteria that would be furnished to the judgment would be too indefinite for precision and reproducibility of recording.

In answer to Dr. Lyon's fourth point I would say (1) that we have never said that the result is due to color value alone. As I have already pointed out, composition of light has not yet been ruled out as a factor. Dr. Lyon would not contend, I believe, that the two lights in question are inconsiderably different in composition. (2) We have called the light of the 3 per cent. ceria mantle unsaturated yellow and that of the type C lamp unsaturated yellow, nearly white. The difference thus is in saturation, not in hue. (See also answer to Mr. Cravath.)

In reply to Dr. Lyon's last paragraph I would like to ask whether the difference in the physical efficiency of the different mantles has not both from the point of view of the producer and the consumer, been a factor in the selection of mantles. That there should be any marked antipathy on the part of the public for mantles giving a yellow or orangish light seems strange in view of the great popular sentiment for the light of the kerosene

flame. If I remember correctly Dr. Lyon himself stated on the floor that if they sold the mantle which gives the best light for the eye by our tests they could not pay the janitor. If this be true the fact is greatly to be deplored, for by our testing and non-testing results it gives an excellent light for clear and comfortable seeing.

CHARLES O. BOND: 1. It is always interesting, when some new or short method of arriving at a conclusion has been advanced, to try it out as thoroughly as possible against the conclusions reached by long experience. If the short method results agree with the long method results, then there should be a quick adoption of the former in the interests of economy. As Professor Ferree has recalled, there seemed to be a long standing preference for the light of the kerosene student lamp; and this preference has been sustained in his findings, since the rating of the kerosene lamp is among the highest as a non-producer of fatigue under continued reading.

I had expected, therefore, to hear testimony from the Welsbach Company to the effect that their "Amber Light" mantle which is distinctly yellower than their standard 1 per cent. ceria, 99 per cent. thoria mantle, had been accorded a more favorable reception than the latter, and that this could be proved by sales figures. The reverse, however, seems to be true; in general the whiter mantles are asked for, and it is the opinion expressed by those who have sold them most largely that the customer desires the "whiter, brighter" effect of the standard, and even of the lower ceria content mantles. This is not based on illumination *intensity* it must be noted.

Coincident with this statement in regard to the *color* of *mantles,* it is interesting to note the development of preference in the matter of shades that are to be used with them. The sombre tints and the striking colors as well gradually lose vogue and we find the *amber* colored shades are increasing in use. It is a curious thing, therefore, that while the amber light is not so much desired as the white, yet the modification of the white to an amber tint either by reflection or transmission is desired. It leads to the question of whether there is any intrinsic and measurable difference between the two which Professor Ferree can record as a matter of additional interest.

2. It surely would be worth while also for the authors to devote time to such experiments as would result in a simplification of their method, so that with home made apparatus and following such instructions as they might outline, a great number of interested persons could participate in the accumulation of an amount of data which would be decisive.

C. E. FERREE (In reply): (1) I would point out again that thus far we have gotten our best results with *daylight*, which finding Mr. Bond will agree has also an extensive and long standing confirmation by popular opinion.

(2) I am interested to know whether any attempt at analysis has been made of the sales reports of the Welsbach Company. If the public prefers the amber shade it would seem that in the end they want the amber rather than the greenish effect. The higher luminous efficiency of the standard mantle is well known by measurement in technical circles, and the public must have learned it by experience. The combination of the higher efficiency mantle with the amber shade seems to me to be a very *human* compromise between thrift and comfort; as a matter of fact, as Mr. Bond suggests, the standard mantle with the amber shade may give approximately as good an effect on the eye as the amber mantle with a neutral shade. It would be of value, I think, to have comparative data on these two combinations of mantle and shade both with regard to their luminous efficiency and their effect on the eye. In all of the discussions of the relative merits of illuminants the advantage of the comparatively low surface brilliancy of the gas mantle should not be forgotten. This fact is of a great deal of importance in the practical problem of providing adequate shading for the eye.

We are puzzled that any one should call the light of the 1 per cent. ceria mantle of the Junior size white. The reading page illuminated by this mantle was in our experiments unsaturated yellow (less saturated than for the amber mantle) with a pronounced greenish tinge. In the 0.7 per cent. ceria mantle the green was still stronger, in fact dominant. Perhaps mantle color is confused here with color of the reading page as illuminated by the mantle. The high brightness of the mantle gives it when viewed directly a much less colored appearance than the reading

page illuminated by it. Compare, for example, the surface brightness of our reading page, 0.00344 candlepower per square inch with the surface brilliancy of the mantle itself. In this connection it should be remembered that even the spectrum colors are seen as white when their intensity is sufficiently increased. Obviously in studying or rating the effects of different illuminants on the eye we are concerned with the coloration of the light which falls on the work, not that of the mantle.

In concluding, in view of all that was said on the floor, much of which does not appear here, I think it is only fair to give in closing a little of the history of the present experiments. They were undertaken because of a request made by certain members of the Society, connected with the gas industries, that we test the effect of two mantles represented to us as commercial. Certain differences in effect were obtained. As a result the present series of mantles were made for us under their direction to determine the effect of varying the proportions of ceria and thoria. We had no responsibility for planning the series or for arranging the details of installation and operation of the units. All such matters were taken care of by them. The tests were made under their direction and all of the conditions from their side and ours were inspected by them before and during the course of the work to see that justice was done. At the end of the work, when all of the results were in, another inspection was made and conference held. The opinion was given that the tests had been conducted under fair conditions. The desire was expressed that the testing be extended to include a large number of observers. We are much indebted to these men for a fair, sympathetic and thoroughly unprejudiced co-operation.

TRANSMISSION OF COLORED LIGHT THROUGH FOG.*

BY C. L. UTTERBACK.

It is the purpose of this investigation to study the transmission of lights of different wave lengths through a fog.

A quantitative determination of the density of the fog was not attempted, but care was taken to reproduce as nearly as possible the conditions upon which the density of the fog depends. In all instances a sufficient number of fogs was produced so that the average of the readings for the different wave lengths represent the effect of a fog of nearly constant density.

Measurements were made on thick, medium and slight fogs, but the data given here is for the medium fog only. What is here called a medium fog is about the density of our moderate fog.

Apparatus.

In order to compensate for the small absorption of light it was necessary to use a long tube filled with the fog. The apparatus is shown in diagram in Fig. 1. It consists of an air tight, as-

Fig. 1.

bestos-covered tube, A, of galvanized iron, 190.5 centimeters in length and 16 centimeters in diameter. In the middle of its length was a box of the same material 40 centimeters square.

* Paper presented before the Philadelphia Section of the Illuminating Engineering Society, Philadelphia, Pa., March 21, [illegible]

The source of light was a 6-8 volt, 21 candle power automobile lamp, B. The light was made nearly parallel by a condensing lens at C. In front of this lens was located an adjustable circular opening, D, by means of which the size of the beam of light was regulated. The beam was passed through the tube and allowed to fall on the Illuminometer plate, E, where its intensity was measured by means of a Macbeth Illuminometer. The ends of the tube were closed by glass plates and were made as nearly parallel as possible. At F, small glass windows were placed in order that any scattering of the light might be observed. Thermometers were placed at G. Glass tubes at H and J connected with the inside of the tube A. The one at H was used for the introduction of water. This was necessary in order to keep the air in the tube saturated with water vapor. The opening at J was connected by means of a T-tube to a mercury manometer and to the large glass jar, K. This jar was connected to the air pump. Between the jar and the observation tube, A, was placed the ground glass valve, L, so that the air in the tube could be expanded very suddenly after the jar had been evacuated to any desired pressure. The inside of the tube was painted a dead black to prevent the reflection of any scattered light.

Method of Making Observations.

The light was made to pass through the empty tube and its intensity in foot-candles at E was measured. The lamp was kept constant at 8 volts throughout the measurements. With the valve, L, closed, the pressure in the jar was reduced a known amount. Then by opening L the air in A was suddenly expanded and the resulting cooling produced the condensation of the water vapor. The intensity of the light at E was again measured.

It was found that by expanding the air in A to the same pressure, i. e., a reduction of 1.1 centimeters of mercury, and by keeping the space from which air was drawn into the tube each time well filled with dust particles, that a fog of practically the same density could be reproduced. The intensity of the white light transmitted through the fogs varied by less than one per cent. No other method for determining the density was attempted.

The different wave length ranges were obtained by means of absorption screens.

In some instances readings were taken on 6 fogs for one wave length range, in others 10 readings, and in one case 20 readings. The number of readings depended upon the intensity of the light under observation.

The transmission bands of the screens were measured by means of a Hilger direct reading spectroscope, employing the diffraction grating. The lamp used in these determinations was the same one used for transmitting the light through the fogs.

Table I shows the transmission bands and the mean wave length for the various screens. Nos. 12 and 13 are for the Conaphore Auto Lens and the Westinghouse Daylight Lamp glass, respectively.

The average temperature throughout the investigation was 19.5° C.

At no time was there enough scattered light to be detected at the windows F.

The observed and calculated data is recorded in tables II and III.

An accuracy in observation of approximately one per cent. was obtained.

TABLE I.

Screen No.	Transmission band	Mean λ
1	5908-6755	6331
2	5800-6520	6190
3	5675-6305	6020
4	5520-6320	5920
5	5770-6150	5960
6	5070-6070	5570
7	5118-5675	5396
8	5052-5655	5303
9	5015-5465	5240
10	4390-5480	5215
11	4280-4630	[illegible]
12	4020-6230	[illegible]
13	4100-7070	[illegible]

TABLE II.

Mean λ	Part of spectrum	No. fog: Illuminometer readings	No. fog: Illumination in ft.-candles	Fog: Illuminometer readings	Fog: Illumination in ft.-candles	Per cent. trans.
Light from lamp		4.00		2.32		
		4.00		2.33		
		3.98		2.32		
		4.00		2.34		
		4.00		2.31		
	(mean)	3.99	3.99	2.32	2.32	58.1
6331	Red	8.40		5.00		
		8.40		4.98		
		8.60		5.15		
		8.40		5.16		
		8.30		5.16		
		8.40		5.11		
	(mean)	8.42	0.74	5.09	0.45	60.4
6190	Orange	8.08				
		8.04				
		8.09		5.05		
		8.10		5.08		
		8.08		5.00		
		8.09		5.01		
		8.11		5.07		
		8.08		5.06		
	(mean)	8.08	0.71	5.05	0.44	62.5
6020	Orange-Yellow	4.40		3.75		
		4.38		3.74		
		4.39		3.80		
		4.44		3.71		
		4.42		3.73		
		4.40		3.72		
	(mean)	4.41	0.08	3.74	0.07	84.8
5920	Yellow	2.00		1.78		
		2.02		1.76		
		2.03		1.75		
		1.98		1.76		
		2.03		1.76		
	(mean)	2.02	2.02	1.76	1.76	87.1
5860	Yellow	2.00		1.78		
		2.04		1.78		
		2.02		1.76		
		2.03		1.78		
		2.06		1.74		
		2.04		1.76		
	(mean)	2.03	0.04	1.77	0.03	87.2
5570	Yellow	9.80		8.52		
		9.80		8.54		
		9.80		8.50		
		9.81		8.48		
		9.81		8.54		
		9.80		8.56		
	(mean)	9.80	0.86	8.53	0.75	87.0

TABLE II. (*Continued*)

Mean λ	Part of spectrum	No fog: Illuminometer readings	No fog: Illumination in ft. candles	Fog: Illuminometer readings	Fog: Illumination in ft. candles	Per cent. trans.
5306	Green	2.80		2.40		
		2.77		2.40		
		2.77		2.46		
		2.81		2.38		
		2.81		2.45		
		2.80		2.46		
	(mean)	2.79	0.24	2.42	0.21	87.3
5363	Green	5.11		4.59		
		5.12		4.48		
		5.09		4.38		
		5.00		4.42		
		5.06		4.46		
		5.03		4.42		
	(mean)	5.07	0.45	4.44	0.39	87.4
5240	Green	3.88		3.29		
		3.95		3.36		
		3.85		3.30		
		3.92		3.34		
		3.93		3.38		
		3.96		3.34		
	(mean)	3.91	0.34	3.33	0.29	85.2
4935	Blue	2.38		2.08		
		2.42		1.95		
		2.40		1.90		
		2.38		2.00		
		2.40		2.01		
		2.37		2.04		
	(mean)	2.39	0.21	1.99	0.17	82.2
4605	Blue	2.70		2.03		
		2.68		2.02		
		3.00		1.92		
		2.65		2.08		
		2.64		1.93		
		2.70		1.95		
		2.67		1.96		
		2.68		1.94		
	(mean)	2.71	0.05	1.93	0.03	71.9
Conaphore Auto Lens		4.30		3.60		
		4.60		3.56		
		4.30		3.50		
		4.40		3.52		
		4.50		3.50		
	(mean)	4.42	0.39	3.53	0.30	79.7
Westinghouse Daylight Lamp Glass		3.10		1.91		
		3.25		1.90		
		3.30		1.88		
		3.20		1.92		
		3.25		1.91		
	(mean)	3.22	3.22	1.90	1.90	59.0

TABLE III.

Mean λ	Illumination in foot-candles to be delivered to fog to produce 2.32 foot-candles at *E*
Light from lamp	3.99
6331	5.76
6190	5.56
6020	4.10
5920	3.99
5860	3.99
5570	4.00
5396	3.97
5363	3.97
5240	4.08
4935	4.23
4605	4.84
Conaphore	4.36
Westinghouse daylight glass	5.90

The second column of the above table shows the intensity of illumination of different wave lengths necessary to be delivered to the fog in order to produce on the plate E the same illumination as was produced from the uncolored light from the lamp, *i. e.*, 2.32 ft. candles.

Summary of Data.

Table II shows that the transmission is highest for wave lengths from about 5300 to about 5900 and falls off very rapidly toward the red but not so rapidly toward the violet. The difference between the maximum transmission obtained and the lowest transmission in the red is 31.0 per cent. while this difference for the lowest transmission in the blue is 17.7 per cent.

A similar difference was found by Abbott[1] in the transmission of light through water vapor when there were dust particles in the air.

Investigations by Dr. T. Ewan[2] on the transmission of colored light through pure water gave results similar to those found in this study, as is indicated by Curves I and II.

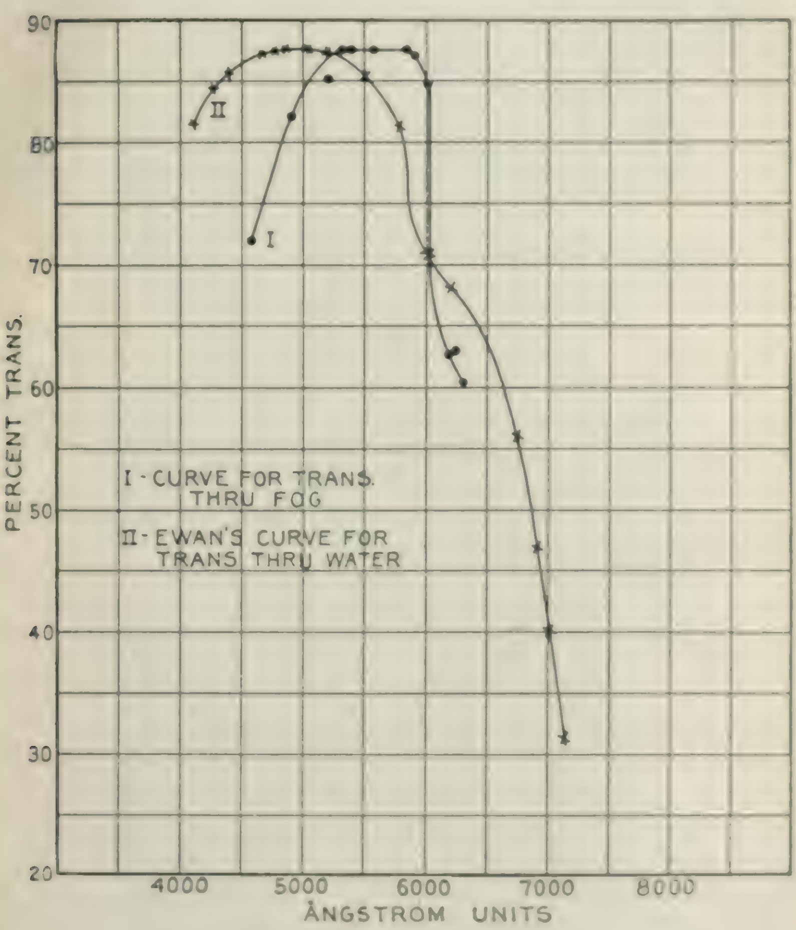
Dr. Ewan's results agree with those obtained by Huffner and Albrecht.[3]

[1] *Annals of the Astrophysical Observatory*, 3:214-18.

[2] *Proc. Royal Soc. of London*, 57:117-162:1894.

[3] *Pogg. Ann.*, 42:1-17:1891.

Curve I is the curve obtained for the transmission through fog. Curve II is the one obtained by Dr. Ewan for transmission through pure water. The maximum transmission through pure water is displaced toward the violet with respect to the maximum transmission through fog as found by the writer.



The mean wave length for maximum transmission through fog is found to be about 5620.

Wave length 5240 is not on the curve. The screen from which this light was taken had a slight transmission band in the red

which had not been taken into account in determining the mean wave length.

Curve I also shows that in order to have maximum transmission through fog, light must be composed of wave lengths between the limits 5300-5900, and must not contain any red or blue, as is shown by the Conaphore lens and the Westinghouse Daylight glass.

Conclusion.

The data of this investigation shows that an automobile light, or any searchlight, will have the maximum transmission through fogs if the light is composed of wave lengths from 5300 to 5900 only.

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DISCUSSION.

T. D. Cope, Assistant Professor of Physics, University of Pennsylvania: It is of interest to compare the results of this investigation with the results of other investigations in the same field. In the *Proceedings of the Railway Signal Association,* 1905, page 291, in a paper on "The Roundel Problem," Dr. William Churchill of Corning, N. Y., states:

"The great absorption of light in an atmosphere laden with water vapor is a well known fact. It is not so generally known, however, that some kinds of light penetrate a fog more effectively than others. Two years ago the German Lighthouse Board instituted a series of experiments to determine the relative percentages of absorption of waves at various points in the spectrum. A spectrum was projected through a box covered with glass at opposite ends and filled with steam condensed to fog by a cold water jacket. Photometric measurements proved that the greatest absorption occurred at the red end of the spectrum with a gradual decrease toward the violet end. Figuring the absorption at the D line as 100, the extreme red showed 108.7 per cent. under the same conditions, the extreme violet 87.7 per cent. These figures are quoted from an unpublished report furnished to the writer through the courtesy of Geheimrat Koerter of the German Lighthouse Board. The results are of considerable interest since they prove conclusively that the tendency of all lights to shift in color toward the red end of the spectrum (the aspect of the sun or moon when just rising or setting being the best known illustration) is not due to the presence of water vapor. The effect of vapor is precisely the opposite.

"One other point which requires notice in this connection is that the light produced by a kerosene flame shows more penetrative power in a fog than some other kinds of artificial light. A striking illustration of this fact occurred a few years ago, when the German Government installed lights of 1,000,000 computed candlepower in an important lighthouse upon the island of Heligoland, superseding an oil light of [illegible] candlepower. The arc light proved of far shorter range in fog than the oil lamps and was accordingly soon discarded. It is true, the arc light shows a preponderance of blue rays which possess a higher penetration in water vapor than red or yellow, but for some reason not clearly understood, the waves emanating from the arc are all very feeble against a fog. Kerosene so far as fog is concerned, is a relatively satisfactory illuminant for signal purposes."

The results of the tests just quoted may be stated to be in substantial agreement with the results of the tests reported by Mr. Utterback.

Mr. M. Luckiesh of the Nela Research Laboratory in a paper on "Yellow Light," read before the Illuminating Engineering Society at Washington, D. C., in September, 1915, reports a test which is of significance in that its results do not disagree with those of Mr. Utterback. Experiments were made with automobile headlights on a foggy night. One headlight was provided with a greenish yellow glass, the other with a white glass. Four observers agreed that distant objects in the fog were better seen by the greenish-yellow light, although the luminosity of the greenish-yellow beam was 25 per cent. lower than that of the white beam.

The effect of a fog in transmitting a smaller percentage of red light and a larger percentage of yellow and green light than of any other color as reported by Mr. Utterback and other experimenters may perhaps be attributed to the selective action of water upon these colors. As is well known a fog consists of small drops of water suspended in the air. In passing through a fog part of the light at least must pass through the water drops. Water absorbs red light strongly and transmits yellow and especially green much better. Red objects when lowered into water lose color and turn black. White objects acquire a greenish color when immersed in water. If an empty tube closed at the bottom with glass be lowered into the water and the white object be viewed through the tube when close to its lower end, its green color is still observed. This shows that the light which penetrates

the water is greenish by absorption. In the current number of the *Journal of the Franklin Institute,* March, 1919, Professor Bancroft of Cornell University gives an interesting review of experiments which prove that water absorbs red and transmits green.

In considering the bearing of the results reported in this paper upon practice it must be remembered that of the factors which tend to reduce the transparency of the atmosphere only one is here investigated, namely, fog, suspended water drops. Small solid particles suspended in the air undoubtedly seriously affect its transparency and in a way differently from fog. The deep red color of the sun observed through smoke or haze indicates that an atmosphere laden with solid particles is best penetrated by red light. The complete study of transmission of light through the atmosphere must involve studies of each of the factors which affect its transparency.

ENOCH KARRER AND E. P. T. TYNDALL: The subject of the transmission of light through fog is an important one in headlight illumination, in military searchlight illumination, and in aerial photography.

The work now under way at the Bureau of Standards on the transmission of light through the atmosphere was undertaken in connection with the tests of military searchlamps.

The subject has a two-fold importance in connection with military searchlamps, *viz.*: (1) in the standardizing and comparing of searchlamps; (2) in the actual use of searchlamps.

In the former case it is necessary to make measurements of the intensity of illumination upon targets at great distances from the searchlamp. It is desirable to know what effect the atmosphere traversed by the beam may have upon the data obtained at different hours of the night and on different nights.

In the second case, a knowledge of the effect of the atmosphere upon a searchlight beam is important from two standpoints:

1. The intensity of illumination at the target and at the eye of the observer is dependent in part upon the transparency of the atmosphere.

2. The seeing of the target is conditioned by the brightness of the path of the beam, through which and along which the ob-

server must look in order to see an object illuminated by the searchlamp.

The path of the beam is made apparent by the diffusion of light by the atmosphere.

It is of interest to divide the mechanisms by which the light is diffused into three, *viz.*:

1. Diffusion by the molecules of gases in the atmosphere.

2. Diffusion by the particles of water and water vapor.

3. Diffusion by the solid particles suspended in the atmosphere.

Examples of the first are, the blue sky and the path of the searchlight beam on clear nights and at high altitudes. Examples of the second may be seen during rainy, foggy and misty weather. Examples of the third are seen in hazy and smoky atmosphere.

The kind of diffusion in the three cases may be different. Diffusion by the molecules and very small insulating particles varies inversely as the fourth power of the wave-length of the light. When the particles become comparable in size to the wave-length of light and larger, this law no longer holds. The exact nature of the diffusion will depend somewhat upon the optical and electrical properties of the material of the particles and upon their shape. This fact is brought out in the differently colored smokes for military and other purposes.

A close study of the diffusion of light by foggy atmospheres has not been made, particularly not during natural fogs.

There is then a point of uncertainty in connection with Mr. Utterback's fogs, as to whether they may be called typical of an outdoor natural fog.

There must have been considerable scattering of the beam by the fog in the tube to account for the low transmission, for, most probably, there was not present a sufficient quantity of water to absorb the light to this extent. It would be interesting to have had on record the amount of water that was actually suspended within the tube. This scattered light should have been detected at the windows (*F* in Fig. 1).

In certain cases the illumination was very low where errors of observation are high. The method of isolating regions of the spectrum by glass screens leaves much to be desired for phenomena of this kind.

There must have been present very pronounced color differences when the fog was present and when no fog was present.

Some preliminary data obtained at the Bureau do not indicate the existence of such pronounced selectivity. Rather there is a definite rise of transmission toward the red even though minor elevations and depressions may be present. This is in accord with general observations by lighthouse engineers.

More work must be done, however, to establish this.

In conclusion it may be said that so far as the detrimental effects of diffusion of light are concerned, blue light is the least desirable kind of light to have in searchlight beams and in headlight beams. The fact that the eye cannot accommodate so well for short wave-lengths is a concurrent cause for pronouncing blue undesirable.

It may be pointed out, however, that for military purposes, blue may be desirable and necessary in detection of camouflaged targets.

C. L. UTTERBACK (In reply to T. D. Cope): The results of the tests performed by Mr. M. Luckiesh have no bearing on the results given in this paper. Mr. Luckiesh determined relative visibility, while the writer measured the intensity of colored light after it had passed through a definite length of fog.

In regard to dust particles in the air; it is, in general, when they are present that fogs are formed in nature. It was only under these conditions that measurements were made.

C. L. UTTERBACK (In reply to Messrs. Karrar and Tyndall): The fogs studied were produced in air which was filled with dust particles and it is believed that such a fog is fairly typical of outdoor fogs, at least in cities.

In quoting from the results obtained by the Bureau no information is given as to the character of the fogs used and, if the contention of Mr. Karrar is correct that the kind of dust particles is an important factor, then his comparison of the selectivity of the two fogs has no point.

The scattering of the beam by the fog in the tube was not considerable as was shown by the failure to obtain readings at the windows, *F*.

The pronounced color difference on the plate *E* were only differences in shade and this difficulty as well as the low illumination was partly overcome by taking a large number of readings for each condition, and by having three different persons take readings.

It is hoped that in the near future a report can be made on the effect of different dust particles in a fog, and also the effect produced by outdoor fogs. The amount of water in the fogs will also be noted.

ABSTRACT—LIGHTING IN WARTIME.*

BY PRESTON S. MILLAR.

The paper describes the place of civilian artificial lighting in wartime, and is written to a considerable extent from the point of view of the Society's Committee on War Service. The paper is treated under four heads respectively: Lighting to promote production; lighting to provide protection; lighting to promote safety; lighting as a field for conservation of fuel.

It has been demonstrated beyond question that high intensity illumination suitable in regard to direction and degree of diffusion is capable of increasing industrial production.[1] The Society's Industrial Lighting Code which has entered into lighting codes promulgated by labor authorities of several states is a most valuable contribution toward bringing about desirable lighting conditions in this connection. The newer lighting equipments in industrial plants, many of which were installed during the period of the war, aided materially in securing the increased production which was necessary. Representations by the Committee on War Service to the United States Fuel Administration brought agreement from officials of the Bureau of Conservation in the proposition that no attempt should be made to save fuel at the expense of industrial lighting except as a very last resort.

In the protection of important property, including public works and ammunition plants, lighting has played a very large part. Its importance was recognized by the Bureau of Plant Protection, Military Intelligence. A pamphlet describing the principles and practice of protective lighting, prepared by the Committee on War Service and issued by the General Staff of the Army, was utilized to excellent advantage. The Committee also functioned in the design of protective lighting installations at the instance of the Bureau of Plant Protection.

* Joint meeting of Chicago Section with Western Society of Engineers, November 25, 1918.

Joint meeting of Philadelphia Section with Philadelphia Section of A. I. E. E. January 13, 1919.

Meeting New York Section, February 13, 1919.

Meeting New England Section, February 18, 1919.

[1] Wm. A. Durgin, "Productive Intensities," TRANSACTIONS I. E. S., p. 417.

Lighting to promote safety has been especially important during the war. It has been estimated[2] that the services of 108,000 men for one year are lost annually because of illumination which is inadequate for safety. An indiscreet attempt to save fuel at the expense of such lighting has been responsible for increased accidents in some plants.

The conservation of fuel has been accomplished through curtailment principally of display lighting, through improvement in lighting methods which have decreased fuel consumption, and through the elimination of waste. The consumption of fuel in artificial lighting is relatively so small that only a small part of the total conservation of the country can be accomplished in this field. Relatively, however, a very large amount of fuel has been saved. Curtailment of show window lighting in particular has brought a realization of the dependence of merchants upon this form of advertising the real value of which was perhaps not fully appreciated before. Indiscriminate curtailment of lighting in the home and elsewhere was contemplated by the U. S. Fuel Administration, but was not attempted as a permanent policy probably in part because of unfavorable representations by the Committee on War Service. Curtailment of lighting in semi-public places including stores was contemplated by the Fuel Administration, but the unexpected cessation of hostilities and the improvement in the bituminous coal situation made it unnecessary to take this step.

The most constructive conservation measures were of course the elimination of waste and the improvement of practice in respect to both of which considerable progress was made during the war. In this respect a pamphlet prepared by the Committee on War Service entitled "Wartime Lighting Economies"[3] and widely disseminated, proved a valuable aid.

An interesting commentary on the changing attitude throughout the period of the war is furnished by the deliberations of the Committee on War Service on the subject of lighting curtailment. At first the spirit of protest prevailed among Committee members. Gradually this disappeared until in the summer of 1918 the members were so impressed with the importance of

[2] R. E. Simpson, "The Relation between Light Curtailment and Accidents," Transactions I. E. S., p. [illegible]

[3] Transactions I. E. S. Vol. XIII, p. [illegible]

saving all possible fuel that they became in spirit amateur fuel administrators.

DISCUSSION.

G. H. STICKNEY: Mr. Millar has described in a very modest way the splendid patriotic service rendered by the Committee under his guidance—one of the proudest things that the Society has ever done. It is well that the members should know about it.

Conditions have changed so that it is not now easy to appreciate the sacrifice and effort which the individual members contributed at times, when they were meeting many severe demands.

Companies permitted their experts to neglect their own business and give extended time to the work of the Committee.

The booklet on "Protective Lighting" was prepared in about one month's time by the splendidly co-ordinated effort of twenty or thirty men.

There was no really established practice. Differences of opinion had to be reconciled. Material from all sources was brought together, supplemented by investigation, and united into a splendid treatise to meet the urgent need of the Government.

As it was a preventative measure, no one will ever know how important it was, what destruction of life and property it was instrumental in avoiding. But we do know that it was considered by those in authority, very necessary to have such a publication, in order to hasten the application of protective measures, without creating undue alarm. We have been given to understand that it met the need.

The German spring drive came and proved serious, but the anticipated wholesale destruction in this country did not materialize. As one of the many instruments employed in the prevention, we may be very proud of this treatise.

Much of the later work of the Committee was rendered unnecessary by the signing of the armistice, but the service was performed and ready for use had the emergency demanded.

So essential was this work regarded by the Council, that the Committee was reorganized last fall to include the whole Society, under the direction of an executive committee.

Mr. Millar's reference to Mr. Noyes' remarks about weighing fuel consumption against the lives of American soldiers, illustrates some of the serious problems this Committee had to decide.

It took courage to recommend sacrifice of lighting and business dependent upon it. It hurt to sacrifice the ideals of lighting practice for which the Society had been struggling. But, facing the issue, the Committee made the patriotic choice. I firmly believe that the program of the Fuel Administration was wiser and better for the country and even for the lighting business on account of the expert advice rendered by the Committee.

There was a marked tendency on the part of manufacturers to cut down on their lighting, thinking it was a patriotic move, and not realizing that it would reduce production. I am sure that the manufacturing program of the Government was in quite a degree safe-guarded by the Committee's warnings regarding industrial lighting.

S. E. Doane (Communicated): The war has served as nothing but an emergency could have done, to give us a clear vision of what principles, practices and forms of organization are most potent in promoting our industrial success and the national welfare. It has been gratifying to find that the Illuminating Engineering Society was so organized as to be able to respond effectively and without delay to a great variety of calls for assistance from the various Government departments. This Society was peculiarly fitted to serve the national interest, for unlike most technical organizations, its major function has always been that of teaching, in a broad and comprehensive manner, fundamentals of good practice the validity and value which have been emphasized in these times. We may well be pleased that the intensive work carried on during the few years of the Society's existence had already added greatly to the effectiveness of industry and the protection of life and property. The principles and practices advocated in the papers before us are in the main as important in peace as in war, and their application will continue to promote progress.

That our work in assisting American industry must be taken up with redoubled effort, is brought home to us forcibly in the report of Mr. Durgin's investigations. Our contributions on lighting intensities have so far gone largely to form the basis of the levels necessary from the standpoints of safety and conservation of vision, which properly form the basis of governmental regulations covering lighting conditions in industries. But our

industrial leaders are demanding more of us, *viz.*, a guide of practice in illumination which will lead to most economical production. Before such a guide can be promulgated a vast amount of investigation must be carried on in the various industries, and this may well engage the efforts of a large number of our membership.

H. D'OLIER, JR.: Mr. Millar's paper mentioned Mr. Durgin's work along definite lines "increased intensity of shop lighting." When he saw the slides of the shipbuilding plants, the views that most indelibly impressed us were the ones where the lighting conditions appeared excellent and of high intensity.

The papers seemed to lay great stress on the very great value of much light for industrial activities during the war. Why, then, in peace time, should not the same increase of lighting conditions be needed?

The illuminating engineer of course knows and believes that lighting of high intensity, or increase of artificial light, will give results well worth the expense and I hope the Society continues definite active work so as to cause this truth to be universally believed. Commercially, stress has been laid on articles such as reflectors, glassware and lamps for industrial plants, while the one main issue takes second place. Now if the principle of increased intensity could be established, all commercial conditions would be much helped.

We know that our bodies need food of value, calories, also work and rest, and that patent medicines are a thing of the past. So it would be with industrial lighting if we could have the real value of increased intensity understood. We then would see the ancient lighting system of so many varieties disappear and in its place see the illuminated shop stand out so beautifully that the light source would become little noticed.

Going through the many plants tremendously active in production during the war, only proves the great need of increased intensity, the variety of all sorts of lighting sources being most amusing.

So the impression that I want to emphasize is that there is one standard in lamps, glassware, reflectors and installation of engineering practice, and that is, quantity of light properly diffused.

ABSTRACT—LIGHTING FOR PRODUCTION.*

BY WM. A. DURGIN.

By means of a factory model showing cross section of a typical machine shop and a translucent working plane, the effects of modification of several factors in daylighting were demonstrated in comparison with the results obtained from the usual local lighting systems in practice.

The intensity, shadow production, and uniformity of the lighting was considered, the treatment leading up to the superior results obtained from a general lighting system giving productive intensities. The value of this type of installation was shown by the detailed data obtained from four careful tests in industrial plants where the actual production under the high intensity could be compared with that when the old low intensity systems were used.

Examples of several recent units in the 300-watt size were exhibited, and emphasis placed on the special adaptation of each to certain classes of installation.

* Paper presented before the Chicago Section, Chicago, Ill., on February [illegible]

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PRESENT STATUS OF INDUSTRIAL LIGHTING CODES.*

BY G. H. STICKNEY

ABSTRACT OF PAPER.

In order to protect workers from accident and eye-strain, industrial lighting codes have been adopted in four states and in Federal establishments. Similar action is under consideration in several other states and there is prospect of extension throughout the country.

Investigation and experience indicate the need of Government regulation of factory lighting. When adopted by industrial commissions under authority granted by legislatures, the codes become in effect state law. Variations in the codes as adopted are less than might appear, some features being experimental. The existing codes correspond in essentials to the Illuminating Engineering Society code, on which they are based.

Mandatory regulations are necessarily limited in function to the assuring of safety. Higher standards are essential for efficient production. Popular education in which electrical and illuminating engineers can co-operate is an important feature of future development.

INTRODUCTION.

The industrial lighting codes are expressions of the "Safety First" movement in terms of legal regulations directed to the lighting of factories. The prime function of these codes is the safeguarding of life, limb and vision of industrial workers. No argument should be necessary to enlist the support of all good citizens to such a humanitarian effort. In addition, the codes seem likely to teach practise which will enhance the earning power, not only of the workers themselves but also of the industrial plants. This incidental result seems likely to be of great economic importance in the coming period of international com-

* Paper presented before a joint meeting of the American Institute of Electrical Engineers and Illuminating Engineering Society at New York, N. Y., Mar. [illegible]

petition. Sufficient progress has been made in the application of these codes to indicate that such regulations will ultimately be in force throughout the country. Through their relation to lighting practise, these codes seem destined to have a broad influence on electrical engineering, and it is the purpose of this paper to inform electrical engineers regarding the scope and tendencies of these codes, as interpreted from a close association with the work and with those responsible for it.

Industrial lighting codes, based on the Illuminating Engineering Society's code, are now in force in the states of Pennsylvania, New Jersey, New York and Wisconsin. In several other states similar codes have been drawn up and are under consideration for adoption. In others, bills looking to the adoption of the code have been introduced before the legislatures. As a war measure, the Advisory Commission of the Council of National Defense, through its Committee on Labor, appointed a sub-committee known as the Divisional Lighting Committee, to encourage the movement. The sub-committee, working through state representatives, has approached the authorities in each of the states to encourage the adoption of such codes. As the result of this activity, progress has been made toward the introduction of an industrial lighting code or, a safety code, by the Departments of Labor, Industrial Accident Commissions, or other agencies charged with the enactment and enforcement or regulations in regard to factory lighting.

Through co-operation of the Bureau of Standards and the Federal Inspectors of Safety, a lighting safety code was adopted during the war, in all Federal establishments, including arsenals, munition plants and navy yards.

NECESSITY.

The necessity for such regulation is well explained in the introduction to the new edition of the Wisconsin code, which reads as follows:

> Insufficient and improperly applied illumination is a prolific cause of industrial accidents. In the past few years numerous investigators, studying the cause of accidents, have found that the accident rate in plants with poor lighting is higher than similar plants which are well illuminated. Factories which have installed approved lighting have experienced reductions in their accidents which are very gratifying.

> Of even greater importance, poor lighting impairs vision. Because diminution of eyesight from this cause is gradual, it may take the individual years to become aware of it. This makes it all the more important to guard against the insidious effects of dim illumination, of glaring light sources shining in the eyes, of flickering light, of sharp shadows, of glare reflected from polished parts of the work. To conserve the eyesight of the working class is a distinct economic gain to the state, but regardless of that, humanitarian considerations demand it.
>
> Finally, inadequate illumination decreases the production of the industries of the state, and to that extent, the wealth of its people. Factory managers, who have installed improved illumination, are unanimous in the conviction that better lighting increases production and decreases spoilage.

Illuminating engineers have recognized for a long time that inadequate lighting was responsible, in a greater or less degree, for industrial accidents, and that good lighting was a potent means of accident prevention. Extensive data, accumulated by John Calder,[1] R. E. Simpson,[2] and others provide convincing proof of this condition.

The loss of visual power, through improper lighting, cannot be so readily recorded, and hence is not so directly substantiated by actual data. It is, however, recognized as a serious menace by oculists[3] and others. Because it incapacitates the skilled worker just when he should be most valuable, and further, because the danger is not readily recognized by those immediately responsible for industrial lighting, the necessity for governmental supervision is even greater for this purpose than for the prevention of mechanical accidents.

In spite of the recent general improvement in industrial lighting practise, the increasing need of ample assurance in this matter is evident from the present tendencies of manufacturing, among which may be mentioned the following: the grouping of larger number of employees; the extension of all night processes; increasing use of dangerous machinery; intricacy of processes and specialization of workers requiring sustained visual application.

HISTORICAL.

Practically all the codes in force or under preparation are based on the "Code of Lighting Factories, Mills and other Work

[1] For references, see Bibliography.

Places" of the Illuminating Engineering Society,[4] and conform closely to it in all essentials.

This code was prepared by the co-operative action of the Committee on Lighting Legislation, under the chairmanship of Mr. L. B. Marks, and the former Committee on Factory Lighting, under the chairmanship of Professor C. E. Clewell.

The Illuminating Engineering Society was called upon in 1913 to assist in formulating the lighting section of the labor law of New York State. It was found impracticable then to incorporate definite lighting specifications in the law, and so provision was made in the law for the later adoption of such regulations, by the Labor Commission. In preparation for the Commission's requirement, work of drafting a code was undertaken. The problem proved a very difficult one and many modifications were found necessary, even after its first publication. Various societies, many engineers and state commissioners pointed out desirable changes, which were incorporated from time to time. Even at the present time, although the code is a very valuable working instrument, it is considered, by those who have had most to do with it, to be under development and liable to slight changes and amplifications, with the development of the art and with increased experience in application of the various provisions.

In 1916 at a meeting in Philadelphia,[5] Dr. J. P. Jackson and Colonel L. T. Bryant, industrial commissioners of Pennsylvania and New Jersey, respectively, became interested, and after introducing some practical improvements, their respective commissions took action which resulted in the adoption of the code in the summer of 1916. The New York Commission adopted the code with some modifications and put it in force July 1, 1918, some of the features being tentative for a year.

The Wisconsin Commission began issuing lighting orders in 1913, but these orders did not contain any specification as to intensity of illumination on the work. After thorough investigation the orders were superseded by the present code, which was issued in May, 1918.

The author has just received word since writing this paper, that the legislature of the State of Oregon has passed a bill establishing an industrial lighting code.

SCOPE

In the states which have adopted codes, the action has been by industrial or labor commissions, under the authority granted them by legislature, to promulgate rules in the interest of safety of industrial workers. The codes are, therefore, backed by the state police power.

Since the function of the Commissions is limited to insuring safety, the codes require only such lighting as is necessary for that end. Under these circumstances the codes cannot demand the higher standards of illumination desirable for economical production.[6] That the intensities specified are minimum limits, consistent with safety rather than good practice, is recognized, and in connection with all the codes, higher values representing more desirable practise are recommended.

It has seemed to be the experience of labor commissions that at least 90 per cent. of the manufacturers cordially desire to comply with their regulations. The principal difficulty so far encountered in applying the codes, has been to make clear to the layman just what is required and how it can be secured. It has, therefore, been found expedient to publish educational sections supplementary to the codes proper. Such sections explain the principles involved and make suggestions for securing and maintaining good installations. The recent revision of the Wisconsin code treats rather comprehensively of the selection and location of lighting equipment, illustrated by charts.

By joint action of the Pennsylvania and New Jersey Commissions, a course of lectures[7] on the interpretation of the codes was given to their inspectors at the University of Pennsylvania in the spring of 1918. A similar lecture[8] was given to factory inspectors of the Board of Labor and Industries of Massachusetts in October, 1918. Doubtless this will be repeated and the method applied elsewhere. The New Jersey Commission has held meetings of contractors and manufacturers, to assist in the educational work.

In all the codes, the employment of expert engineering or architectural advice is recommended.

SPECIFICATIONS.

The principal lighting specifications common to all states which have adopted the code, are intensity, glare limits, and distribution.

It is also usual to require provision of emergency lighting, watchman's circuits and certain switching provisions. In some cases these features are omitted from the codes, being provided for in the law or elsewhere.

A comparison of the codes adopted or under preparation shows a remarkable uniformity in the specification of these factors. There is some variation, especially as regards experimental features, but this is of a nature likely to help rather than retard the development of codes toward excellence and uniformity.

In drawing the specifications, it has been constantly recognized that they must be kept simple and practicable so that conformance could be determined without recourse to lighting experts or bulky and expensive instruments. On the other hand, it is desirable to make the specification as definite as possible, minimizing the part left to individual judgment and thus avoiding controversy and prejudice.

DAYLIGHT.

While it has been considered desirable to require that new buildings and extensions be so constructed as to provide adequate daylight, it has been found very difficult, if not impracticable, to lay down a definite rule, and in most of the codes it has been assumed that the purpose was accomplished if suitable artificial light were required where and when daylight is unavailable.

Daylight is subject to a wide variation throughout the hours of the day, seasons of the year, with changes in weather and for different directions of window exposure, etc. In any building the natural lighting may be affected by surrounding construction on property not under the control of the owner. A work-room having ample daylight when erected may be darkened by later construction. In a dense manufacturing center, *e. g.*, downtown Manhattan, it would be impracticable to realize so good a condition, especially on lower floors, as might be reasonably required of a suburban factory. Some reasonable provision can undoubtedly be reached, which will at least require the minimization of glare and provide for wide distribution of light, by the use of suitable awnings, shades, refractive windows, etc.

The Wisconsin Commission has adopted the following rule in this connection:

Order 2111. Natural Light. Windows, skylights, saw tooth or other roof lighting construction of buildings shall be arranged with reasonably uniform bays and the glass area so apportioned that at the darkest part of any working space, when normal exterior daylight conditions obtain (sky brightness of 1.5 candlepower per square inch), there will be available a minimum intensity equal to twice that of Order 2112 for artificial light.

Awnings, window shades, diffusive or refractive window glass shall be used for the purpose of improving daylight conditions or for the avoidance of eye strain wherever the location of the work is such that the worker must face large window areas, through which excessively bright light may at times enter the building.

Note: The intensity requirements for adequate daylighting are much higher than those for adequate night lighting, because in general, under daylight conditions, the light coming to the eye from all the surroundings in the field of vision is much brighter than at night, and hence a correspondingly more intense light must fall on the object viewed.

It is the almost universal experience of illuminating engineers and others, that it is possible to operate satisfactorily with a lower intensity of artificial than natural illumination. The reason for this has not been satisfactorily explained; but with daylight the relatively high illumination of walls and other surrounding objects, compared to the illumination on the work, is undoubtedly a contributory cause.

In the earliest draft of the Illuminating Engineering Society's code, a ratio of 3 to 1 between natural and artificial lighting requirements was specified. Later this was changed to 2 to 1, and still later, in the absence of definite data in confirmation of the necessity of higher daylight intensities, artificial lighting was required when daylight intensities fell below the values specified for artificial lighting. The Wisconsin code and one or more of those under preparation, have adhered to the ratio of 2 to 1, which figure has also been used in the Illuminating Engineering Society's School Lighting Code. Further experience is apparently necessary before any final relation can be determined.

It is probable that in different conditions of daylight and of artificial light, the relative value varies. It is not likely, at least in the near future, that actual foot-candle measurements will become the criterion for turning on the lighting, so that an accurate determination of this ratio does not seem to be of immediate importance.

The Illuminating Engineering Society, Pennsylvania, New Jersey and New York codes are essentially artificial lighting codes and do not attempt to specify daylighting. On the other hand, serious conditions of glare are not infrequent in the natural lighting of workrooms, and the extension of the code to mitigate such conditions seems to have considerable merit.

From a hygienic standpoint, sunlight has desirable features distinct from its relation to vision, so that it is desirable to have daylight available wherever possible.

There are some processes which inherently require the exclusion of daylight. Moreover, in large cities, workrooms, such as engine rooms, pipe shops, etc., have been established in basements, apparently without serious harm to the workers. On a larger scale, workrooms have been established above ground, which require artificial lighting throughout the day.

Unquestionably, all visual requirements can be provided with proper artificial lighting. It is, therefore, doubtful if a mandatory requirement of daylight for all places is justifiable. One of the codes under preparation, but not yet adopted, meets these conditions by simply specifying the lighting features necessary without distinction as to whether the light is natural or artificial.

INTENSITY SPECIFICATION.

In all the codes which have come to the author's attention, intensity is specified in foot-candles. While at first some difficulty was anticipated in explaining these values and providing for their measurement, the development of an inexpensive and simple "foot-candle meter" has facilitated the application of these specifications.

For yards, passageways, aisles and stairways, the intensity on a horizontal plane, at or near the floor level, is assumed for measurement.

For various operations, the intensity is required at the work and would naturally be measured in the plane of any surface requiring vision of the character indicated. In all cases the limits are given as minima, not averages.

It has been generally recognized in selecting the intensity levels that there are no definite critical points, where a variation of a small percentage, one way or another, would cross a definite line

between safety and danger. In determining the various intensity levels, lighting experts have drawn on their experience, supplemented by special investigation. It inspires confidence to note that the American values correspond rather closely to those determined independently in England after a very exhaustive investigation under governmental auspices."

The intensity specifications naturally fall into two groups: those required over general spaces and those required for work operations. The former are primarily for the prevention of accident, while the latter have the added element of conservation of vision, especially in the higher intensity classes.

A lower standard is allowed out-of-doors than indoors, on account of the difference in the usual character of surroundings and the nature of travel. The large out-of-door areas must, for economic reasons, have a low intensity requirement, and it would not be reasonable to demand much more than ordinary street lighting or moonlight intensities. The value of 0.02 foot-candle, therefore, appears in all the codes. For interior lighting a minimum of 0.25 foot-candle has been required for all traversed spaces.

New York and Wisconsin have included a classification to cover elevators, washrooms, dressing rooms, etc., at 0.5 foot-candle. This has not appeared in the earlier codes, but seems to be a useful addition.

The lowest intensity for manufacturing under the Illuminating Engineering Society, Pennsylvania, New Jersey and Wisconsin codes is 1.25 foot-candles. New York has adopted 1 foot-candle for the corresponding class, *i. e.*, rough manufacturing. While this value is, in the opinion of some engineers, lower than desirable, there is doubt if there is evidence to warrant the standardization of the fractional value.

The New York Committee has also adopted a new level of 0.5 foot-candle for the handling of materials and other very rough operations, and this step is being included in some of the codes in preparation in other states.

The higher steps are the same in all codes being located at 2.3 and 5 foot-candles, according to the fineness of vision required by the operations.

While it is true that there are operations requiring more than 5 foot-candles, they are exceptional and usually performed by highly skilled specialists. As such individuals are likely to be able to protect themselves, it has not seemed necessary for governmental authorities to take action.

Exceptions arising from the nature of a few processes are necessary to the illumination intensity requirements, as they appear in most of the codes. The omission has been due to the belief on the part of certain commissions that the exceptions were so infrequent and obvious that they can be taken care of readily and thus avoid misunderstanding on the part of others not entitled to exception.

One of the codes under preparation includes a class of zero intensity, while another lists the exceptions in a note following the intensity rule. This reads:

Note: Some exceptions to the Intensity Rule:

a. There are some operations that are performed in comparative darkness, as for example, photographic processes in the dark room.

b. There are some operations that are best observed by their own light as in the parts of the process of working glass.

c. Some operations are best observed by the "silhouette" method of lighting in which the work is seen against a lighted background in a comparatively dark room, as in some processes of working with dark threads and lamp filaments. In all such cases in which work is of necessity carried on in comparative darkness, special precautions should be taken to properly safeguard the workmen.

A limiting feature of the intensity specification is the rather indefinite descriptive classification of the operations assigned to the various levels. The need of more definite descriptions is well known to all who have undertaken the work of drawing up specifications. It is sometimes important than an inspector or a manufacturer be able to tell without question within what class any particular operation falls. This, however, is not so serious as a superficial consideration might indicate, being somewhat ameliorated by the fact that manufacturing economy should dictate a much higher intensity than required by the codes.

Many efforts have been made to render the specifications more definite, but the problem is much more difficult than appears at first. There are many degrees of fineness in the same type of process as carried on in different shops or even in the same shop.

Lathe work in machine shops, for example, varies in fineness all the way from very rough work down to watchmakers' fineness. An article is made by one manufacturer, say to 0.001 inch of accuracy, while another making nominally the same article works to 0.0001 of an inch or finer.

Several proposals have been made, among which may be mentioned:

a. To make the intensity table simply an index of intensity levels, each indicated by an arbitrary designation (*a*, *b*, *c*, etc.) without any description of the process covered. Supplement this with a complete list of all manufacturing processes, using the symbol to designate the particular class to which each process is assigned.

b. To supplement the present classification with a detailed list of standardized processes.

The latter scheme (*b*) seems to have some advantages provided it is not extended too fast so as to lead to confusion through repeated changes. The New York Commission has adopted tentatively for a year, a list of this sort, but has found it necessary so far to use in many cases the qualifying terms "rough work," "medium work," "fine work," which makes the specification in such cases but little more definite than the general classification.

The first plan (*a*) has some ardent advocates, but has been objected to on the ground that such a list implies an accuracy of description that does not really exist. Another objection is that the space occupied by such a list seemed likely to over-emphasize the intensity specification as compared with other code specifications. It seems quite probable that this method will be tried out in one state, in which case its relative merit will be better determined by experience.

In general, it seems desirable for the ultimate good of all that most states adhere to the broad descriptive specification, while a few experiment with the extensions and determine their practicability. They will then be more readily able to adopt any method which shall have been found especially meritorious.

GLARE LIMIT SPECIFICATION.

The establishment of proper limits for glare is probably more important than even the matter of intensity. While the provision of sufficient light is fundamental, it is also better understood and has a more obvious relation to production. It seems

to be generally agreed that more employees suffer from glare than from insufficient light. Certain lighting conditions are readily recognized as glaring, while others are equally recognized as free from objectionable glare. But when it comes to drawing a definite limit between danger and safety, our present inability to measure or accurately define objectionable glare makes it necessary to utilize a qualitative rather than a quantitative specification.

The I. E. S. Pennsylvania and New Jersey codes simply require that lamps be "suitably shaded to minimize glare," with an explanatory note that glare from lamps or unduly bright surfaces produces eyestrain and increases accident hazard. This is supplemented by the requirement (under "Distribution of Light on Work") that "sharp contrasts of intensity" on the work be avoided.

The New York code requires that "exposed bare lamps, located less than 20 feet above the floor, shall be provided with shades, reflectors, diffusing glassware or other accessories, to eliminate or minimize glare." Sharp contrasts of intensity on the work must also be avoided.

The Wisconsin code goes a little farther and says:

> Lamps suspended at elevations above eye level less than one-quarter their distance from any position at which work is performed, must be shaded in such a manner that the intensity of the brightest square inch of visible light source shall not exceed 75 candlepower.
>
> Exception: Lamps suspended at greater elevations than 20 feet above the floor, are not subject to this requirement.
>
> Note: (*a*) Glare from lamps or unduly bright surfaces produces eyestrain and increases the accident hazard.
>
> The brightness limit specified in this order is an absolute maximum. Very much lower brightness limits are necessary in many interiors illuminated by overhead lamps, if the illumination is to be satisfactory. In some cases the maximum brightness should not exceed that of the sky (1.5 to 3.0 candlepower per square inch).
>
> Note: (*b*) Where the principal work is done on polished surfaces, such as polished metal, celluloid, varnished wood, etc., it is desirable (but not mandatory at present) to limit the brightness of the lamps in all downward directions to the amount specified in this order.

For local lighting the Wisconsin code establishes the limit of 3 candlepower per square inch, whenever visible from any

working position. This lower limit is selected "because the eyes are more sensitive to strong light received from below."

There is a difference of opinion among illuminating engineers as to the proper values of candlepower per square inch to be applied to this specification, while some think a better principle of specification can be determined. It has been suggested that glare be specified in terms of contrast of brightness, perhaps expressed in ratios. Some experimental work has been done along this line and at least two experimenters have made up experimental instruments for measuring ratios of brightness. It is recognized that there is a considerable range in the permissible contrast for different processes for different directions, especially of elevation, and for different intensities.[10]

It therefore seems likely that sometime in the future the codes will have some sort of glare classification corresponding to the intensity classification. But advance in such a direction cannot be made until further investigation and development has provided a reliable basis.

Considerable space has been devoted to the engineering limitations of the present glare specifications, with the view of interesting experimenters and engineers in the solution of the problem. On the other hand, the present specifications must not be regarded in any way as a failure. They are practical, working specifications which will do much to improve lighting conditions. They provide the means of eliminating practically all conditions which constitute a serious menace, and while the lack of a defined limit may in some cases be taken advantage of by either the manufacturers or the inspectors, such instances are likely to be quite exceptional. In reality the present specification is more definite than many existing legal requirements in force regarding matters other than engineering.

DISTRIBUTION OF LIGHT.

The New Jersey code reads: "Lamps shall be installed in regard to height, spacing, reflectors or other accessories, so as to secure a good distribution of light on the work, avoiding objectionable shadows and sharp contrasts of intensity."

The distribution of light is partly taken care of in the intensity and glare limit specifications. That is, the requirement that

intensity shall not fall below a certain minimum, coupled with economic considerations, tends to avoid a wide variation in intensity, while the latter also requires the elimination of dense shadows on the work. As worded in most codes these rules do not call for the elimination of bright striations of light, or, in brightly lighted rooms, of shadows which may interfere with vision but still have an intensity above the minimum limit.

The distribution of light rule covers these omissions, by calling attention to the relation of lamp equipment and location to light distribution. The lighting effects referred to, if objectionable, are so obvious that they are readily recognized when attention is called to them. Therefore, the rule seems likely to accomplish its purpose without much difficulty.

In the Wisconsin code a further requirement is made that the local lighting shall be supplemented by a moderate intensity of overhead lighting, except when reflection from light colored surfaces produces a general illumination. This renders more definite a feature than is implied by the general requirement of the rule.

EMERGENCY LIGHTING.

Panics, which have occurred in crowded rooms when the lighting has failed at the time of a fire, explosion or other emergency, have emphasized the necessity of avoiding any probability of darkness at such a time. There is, however, a wide variation in the actual needs of different workrooms. For example, where a large number of women workers occupy an upper floor surrounded by dangerous conditions, inflammable materials, etc., continuity of lighting is exceedingly important. But where a small number of employees are scattered over a large ground floor area, with convenient exits and without dangerous conditions, safety can be assured without an elaborate provision for continuity of lighting. Moreover, such provision as would be necessary in the first instance, might be prohibitively expensive for the second.

It has, therefore, seemed necessary to make only a general provision in the code, with the expectation that rulings would be made to cover specific cases, or that the detailed requirements would be supplied later by those having suitable experience. It is more a problem of safety engineering than of illuminating engineering.

The general requirement of the rule, common to most of the codes is: "Emergency lamps shall be provided in all work space aisles, stairways, passageways and exits. Such lamps shall be so arranged as to insure their reliable operation when through accident or other cause the regular lighting is extinguished." In some states the rule has been expanded to include instructions for insuring reliable operation—separate mains or sources of energy being required.

For example, the New Jersey code requires—

Emergency lighting systems, including all supply and branch lines, shall be entirely independent of the regular lighting system and shall be lighted concurrently with the regular lighting system and remain lighted throughout the period of the day during which artificial light is required or used.

Emergency lighting systems shall be supplied from a source independent of the regular lighting system wherever possible. This source of supply and controlling equipment shall be such as to insure the reliable operation of the emergency lighting system when through accident or other cause the regular lighting system is extinguished. Where a separate source of supply cannot be obtained for the emergency lighting the feed for emergency lights must be taken from a point on the street side of all service equipment. Where source of supply for the regular lighting system is an isolated plant within the premises an auxiliary service of sufficient capacity to supply all emergency lights must be installed from some outside source, or suitable storage battery; or separate generating unit may be considered the equivalent of such service.

It is apparent that the question of insuring the source of supply is one which is open to considerable discussion, involving, as it does, the reliability of the generating station and various classes of supply lines. Not only do the characteristics of service received from electric central stations and isolated plants have to be considered, but in some cases gas service and other illuminants.

It is evident that conditions of reliability vary considerably in different instances and that leeway must be allowed according to the merits of the particular cases. Where central station service is employed, it has usually been assumed that independent wiring to the street main provides a sufficient safeguard.

There is a tendency in some quarters to require the emergency lighting to be in operation whenever the regular lighting is in use. This comes from the apprehension of deterioration of unused equipment as well as the anticipation of failure to put the emergency lighting into operation instantaneously. In many

cases simultaneous operation may involve an excessive expense. The provision of an automatic system, with reasonably frequent inspection and tests, should provide ample protection.

Where the system is not electric the automatic control may present more of a problem.

Most of the codes do not specify what intensity of lighting shall be provided. In New York state the emergency lighting is provided for in the law, while the code specifies one-quarter foot-candle as the intensity to be provided. This value, which might be implied from the intensity table, is being considered for inclusion in other state codes. It seems to be the reasonable value to require for exits, stairs, hallways and passageways, and also for the main aisles of large workrooms. It might, however, involve an unnecessarily high investment in lines and equipment, to provide such an intensity in all work space aisles.

SWITCHING AND CONTROLLING APPARATUS.

This provides for the location of controlling switches so that at least pilot or night lights may be turned on at the main point of entrance.

Some commissions have considered it important that watchmen and others should be able to go about safely without lanterns, while others believe that the carrying of a lantern is sufficient. The former certainly has advantages, but may in some instances be unnecessarily expensive.

It would appear that the rule in this form is satisfactory on the assumption that an industrial commission would make exceptions where unnecessary hardship is shown.

ENFORCEMENT.

Attention has been called to the readiness and willingness of the industries to comply with commission regulations, if they are understood.

Other limitations of the code have already been discussed, but none of these has presented more of an obstacle than the fact that many of those by whom the regulations must be applied are not versed in the principles of light and illumination, and have

FIG. —Group of five industrial lighting codes now in force. (Title pages are self-explanatory.)

TABLE I.

ILLUMINATION INTENSITIES

(Foot-candles)

Nature of subject	Illuminating Engineering Society	Wisconsin	Pennsylvania	New Jersey	New York
1. Roadways and yard thoroughfares	0.02	0.02	0.02	0.02	0.02
2. Storage spaces	0.25	0.25	0.25	0.25	0.25
3. Stairways, passageways, aisles	0.25	0.25	0.25	0.25	0.25
4. Toilets and wash rooms	—	0.50	—	—	0.50
5. Work not requiring discrimination of detail; such as handling material of coarse nature and performing operations not requiring close visual application	—	—	—	—	0.50
6. Rough manufacturing requiring discrimination of detail; such as rough machining, rough assembling, rough bench work, also work in basements of mercantile establishments requiring discrimination of detail	—	—	—	—	1.00
7. Rough manufacturing, such as rough machining, rough assembling, rough bench work	1.25	1.25	1.25	1.25	—
8. Rough manufacturing involving closer discrimination of detail	2.00	2.00	2.00	2.00	2.00
9. Fine manufacturing, such as fine lathe work, pattern and tool making, light colored textiles	3.00	3.00	3.00	3.00	3.00
10. Special cases of fine work, such as watch making, engraving, drafting, dark colored textiles	5.00	5.00	5.00	5.00	5.00
11. Office work, such as accounting, typewriting, etc.	3.00	3.00	3.00	3.00	3.00

Fig. 2.– Table of comparative intensities compiled by Mr. H. E. Mahan and appearing in his article on Lighting Legislation in the *General Electric Review* for February.

Fig. 1.—A section of the supplementary table of intensities appearing in the New York State code. This indicates the extent of sub-division attempted.

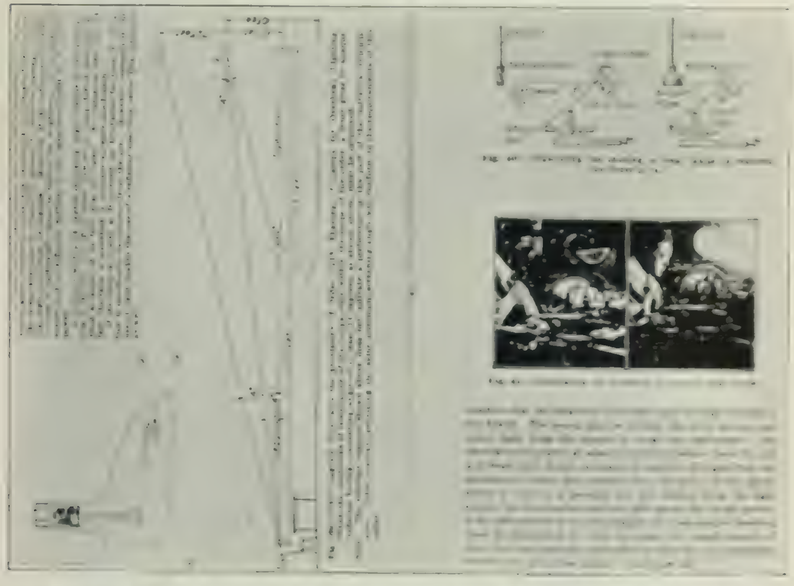

Fig. 3.—A typical portion of the Wisconsin code. This particular section offers suggestions for the elimination of glare and the shading of lamps.

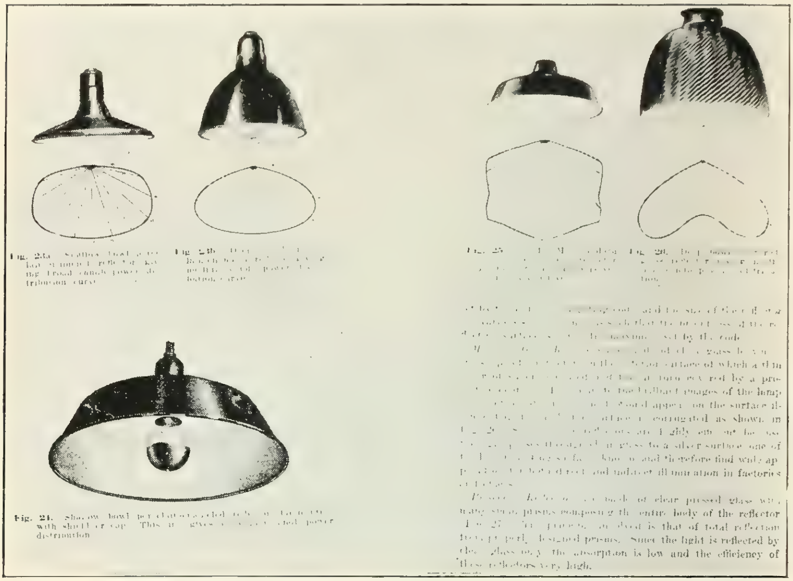

Fig. 5.—In most of the codes a few suggestions are given on the choice of reflecting equipment. This shows the method of treatment in the Wisconsin code. Data of this nature is a valuable adjunct to the successful carrying out of the intent of the Law.

but little idea of the qualities and quantities necessary for the definition of lighting conditions.

Every effort has been made to simplify the rules and make them understandable to others than engineers. Some of the commissions have included simple definitions of terms used. Some have attached explanatory treatises and articles on methods of designing lighting installations. But there is still a need for more popular education. The possibilities of rendering the codes more definite and accurate in the future depend in a considerable degree on such education.

Undoubtedly the commissions can take care of their inspectors but the small manufacturers, foremen and others responsible for the construction and operation of industrial lighting installations need assistance.

The codes and their appendices will undoubtedly provide effective mediums, but the help of those professionally related to the lighting practise is needed. It is earnestly hoped that the individual members of the American Institute of Electrical Engineers and the Illuminating Engineering Society, will inform themselves regarding the principles of the code specification and not only offer constructive criticism but also help in the educational effort of applying the regulation.

CONCLUSION.

The author is inclined to look with apprehension upon laws or regulations emanating from the professions whose business they affect most directly. There has sometimes seemed to be a tendency in such legislation to favor the profession. Such tendencies are presumably more due to the professional viewpoint or prejudice, than to any intent to be unfair.

Having been connected from the first with the committees responsible for the illuminating engineering features, it is only fair to say that the danger of prejudice has been anticipated and carefully guarded against.

Especial care was exercised in the make-up of the committees and the solicitation of criticism, not only to represent the viewpoint of every phase of illuminating and other engineering, but also the light user and light purchaser. The engineer, the scientist and the practical constructor and operator were all included.

On the other hand, it is even more dangerous to legislate regarding such a technical subject without the guidance of the profession. In lighting we have numerous examples of such legislation as, for example, in the headlight laws for railways and automobiles. Many of these laws are not effective or reasonably enforcible, their meaning is not clear, while they not only impose unnecessary hardships, but have in some cases prescribed a dangerous rather than a safe condition.

The industrial lighting codes, besides avoiding both of these dangers, have been so formulated as to encourage uniform action throughout the various states of the Union. The continuation of the code development along the present lines is, therefore, of importance not only to those directly interested in the electrical and illuminating phases, but to the country as a whole.

In discussing the codes an attempt has been made to emphasize the principles involved rather than the details. Changes in details may be expected, but any considerable change in principles seems unlikely. No one is more conscious of the limitations of the code in its present form than the illuminating engineers who have been active in its development, but all who have had anything to do with the work regard it as a valuable working instrument. The author feels safe in saying that they consider it highly important to any state that it be adopted and actively applied as soon as possible. The greatest possibility for future development is through the experience and popular education following its enforcement.

The author has tried to avoid the expression of personal opinion as far as practicable. He has sometimes found it desirable to express his understanding of the views held by committees and their members, but this has been informal and unauthorized and should be so understood.

He herewith acknowledges with thanks the helpful assistance in the way of comment and criticism of Mr. L. B. Marks and Professor C. E. Clewell, to whom perhaps more than to any other individuals we are indebted for the initiation of these constructive regulations.

The author also acknowledges the assistance of Mr. J. A. Hoeveler and others.

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DISCUSSION AT NEW YORK.

by Professor C. A. Adams of The American Institute of Electrical Engineers

While the subject of "Safety Codes" is perhaps not as broadly interesting to the rank and file of the membership of the A. I. E. E., as some suppose, it is one of those things which are being forced upon our attention more and more as time goes on and shows the necessity for taking into account in a serious way the comforts and safety of the user of the things which we have some part in producing and installing.

The Safety Code movement, while in some branches it has been in existence quite a number of years—twenty years or thereabouts—is really only in its infancy. At first we did things as a matter of course because we were interested in the job, and finally we have been forced to take into account the interests of the users, but in so doing we meet with certain other serious difficulties, difficulties in establishing the codes and difficulties in enforcing them, and I think not only the electrical engineers and illuminating engineers, but engineers in general, may take considerable pride unto themselves in that they secured the provision that men trained, in some degree, in engineering, must be employed in these matters.

The great difficulty in the establishment of codes is to not only get them right, but to get the agreement and consent of all those that are affected by them, so that in a matter of this sort it is not only things which have to be considered, but it is the public and users, it is labor unions, and labor, broadly speaking. So that I think that those who have to do with this work, those who have given so much time and thought to it, may feel to a considerable degree comforted, if they do not get much money out of it, in that they are doing a real and vital public service.

I am sure that we all appreciate the amount of disinterested and very serious effort that has been put on a paper of this sort, and back of that the work which has been done on the codes themselves. There are one or two things that Mr. Stickney has said that struck my attention. For instance, in the early part of his paper he said the manufacturers or employers were glad to adopt these codes, because as a rule they meant economies. It would seem natural that a manufacturer would be glad to adopt such codes in the interests of the workers, even though they did

ERRATUM.

The uncredited discussion appearing on page 172 of Vol. XIV No. 4 TRANSACTIONS was contributed by President C. A. Adams of the American Institute of Electrical Engineers. It is suggested that you make correction to that effect on your copy.

not mean economies. I recall a serious shock which I received one day in discussing certain safety devices with a large manufacturer who objected to the introduction of safety devices on a very great number of machines he had, explaining that it was cheaper to allow the accidents to occur and pay the damages. Fortunately, that is not the attitude of many of our manufacturers at the present time, but there are still a few who take that point of view.

C. E. CLEWELL: The importance of legislation along the lines on which Mr. Stickney has so ably presented the subject, seems to me to be evidenced by the interest which has been taken in the several states where these codes have recently been enacted into law. When the subject is viewed from the purely legislative side it would seem that the responsibility for drafting these regulations in such a way that they will be understood both by the manufacturers and the factory inspectors, who are intimately associated with the enforcement of the codes, must rest almost entirely with the state departments concerned.

Mr. Stickney has pointed out the very interesting fact that the various labor departments where these codes have recently been put into effect have depended very largely upon the Illuminating Engineering Society for guidance in drafting these regulations in such a way that they will be suitable to the understanding of those concerned.

I have met and talked intimately with quite a number of factory inspectors, both in Pennsylvania and New Jersey, and have received the general impression that these codes, as obvious as they may appear at first glance, contain matters which, to some extent, are new and the situations created are different from the kinds of things which these inspectors have been accustomed to handling in the past, with other regulations governing the factory equipment. On this account it seems to me that just as soon as there is placed in the hands of an inspector a set of regulations which he is called upon to enforce, and at the same time in the enforcement of which he must depend upon his own judgment, that the thing tends to fail of its purpose in so far as the inspector is not posted on the fundamental principles which are back of the regulations.

The demand which has been placed on the Committee on Lighting Legislation of the Illuminating Engineering Society by these various safety departments, in their requests for something definite, has resulted in a method of procedure which, as far as I can see, is the only method which could have been followed by these committees in the development of the codes as Mr. Stickney has outlined.

Three things stand out in looking over Mr. Stickney's paper: First, that the enforcement of these codes and their ready acceptance on the part of the different labor departments and manufacturers, calls for a certain amount of education; second, that the inspectors who are really the go-betweens, as far as the labor department and the manufacturer is concerned, should have in their hands suitable devices by which they can check up their own judgment when they come to these specifications as to quantity of light and glare which Mr. Stickney has emphasized, and third, that it is almost essential, at least from the standpoint of those who are most intimately concerned with these regulations, to reduce as far as possible the element of judgment on the part of the inspectors, and one of the suggestions which has been made has been the compilation of more elaborate lists of various kinds of work and of the intensities corresponding to the same, so that an inspector may know readily how to place in its proper group any given class of work with which he may be confronted in his rounds of inspection.

The first of these points, the matter of the presentation of the principles contained in the codes, has been handled by a supplementary statement in addition to the regulations proper, which contains much information on lighting and the fundamental principles which govern these regulations, and another item, and what seems to me to be a vital point, is the matter of gathering these inspectors together—because the inspectors as they run are not a fixed group, due to changes which are going on all the time—and a recurrence of these gatherings could be planned, at which the inspectors would receive instruction along the lines of these fundamental principles at first hand. The physical measurement has been cared for, to some extent, by the footcandle meter. As to the matter of covering all the requirements that come up, we must remember that with long lists of working operations and

accompanying tables of intensities, the attention of the inspectors and the manufacturers is likely often to be drawn primarily to the matter of quantity, when there is quite a good deal of feeling on the part of those observing the conditions in the industries, that the quantity of light is not necessarily the most important item, and that the elimination of glare is by and of itself often a more important thing to attack than the matter of quantity.

Another item which I notice Mr. Stickney has dwelt upon, and which is somewhat different from these other items involved in the application of the code is the movement on the part of the New Jersey authorities toward the establishment of a Museum of Safety, so that the manufacturers throughout the state can see assembled in one structure typical types and examples of lighting which will give them some idea of the kinds of things they should watch for in systems of this kind.

The Lighting and Illumination Committee of the Institute, under whose auspices this meeting has been held, is sensible of the opportunity which such a general session has offered for discussion of this topic, and I think we all realize, after hearing Mr. Stickney's paper, that he has not only emphasized the scope and necessity of these codes, but has brought out in an interesting way the relations which they bear both to the manufacturers and to the engineering profession generally.

E. B. Rosa: I wish to emphasize particularly the educational value of this class of work and of the codes after they are issued. It seems as though the educational value would be much greater than the legal value—the benefit to those who are glad to avail themselves of these codes is greater, probably, than the benefits to those who have recourse to the law. I do not mean by that they should not be adopted by legal authority, but I mean to emphasize the very great educational value, first to those who take part in the preparation of the code—it stimulates the study of and education in the subject, and it is of educative value to those who participate in the preparation of the codes; in the second place it is of very great value to engineers to know about these things; and in the third place it is of great educational value to employers, managers and superintendents, those who are responsible for the lighting and the care of manufacturing plants

and other places where lights are needed; and finally, of educational value to the employees, to those who are working in these factories.

While we speak of the compilation as a code, and think of the legal force of it, and the necessity of getting it into form suitable for adoption by legal authority, I think, after all, the educational value of the code is properly more important than anything else.

It is well not to put such codes into force too soon. We believe, in the Bureau of Standards, that these codes—lighting codes or whatever they are—shall be put out and given a trial, and those who are concerned with them given considerable opportunity to become familiar with them, so that the various features of their application may be developed before it is attempted to enforce them strictly. In other words, leave the matter of enforcement to those who are responsible for their enforcement—until they have full opportunity to become familiar with the codes and adapt themselves to the conditions.

C. B. AUEL: The paper on Industrial Lighting Codes by Mr. G. H. Stickney has covered the situation very well indeed, as was only, however, to have been expected from one who has made such a study of lighting as he has, so that further remarks would seem to be largely in the nature of amplification, rather than of bringing out anything additional.

The lighting codes, as is stated in the paper, are an expression of the "Safety First" movement in terms of legal regulations, and with their object everyone without exception will be in full accord. In the main they are excellent; but, regardless of their excellence they, unfortunately, represent individual states only and we shall accordingly probably have inflicted on us eventually as many different lighting codes as there are states in the Union, thus swelling unnecessarily the ever increasing burden of manufacturers and others, especially those doing an inter-state business, in trying to keep abreast of them. Another thing that should be borne in mind is that safety codes can be turned out, comparatively speaking, over night and are also capable of amendment in the same manner, and as they always involve expense while sometimes missing the object sought, they should be most carefully considered from every viewpoint, before being promulgated. Still

another feature that should be mentioned is that all codes are practically a series of instructions to the employers and largely ignore the fact that there are frequently equally important instructions which should be issued to the employees, if the codes are to be successful. Mr. Stickney remarks that the experience of State commissions shows at least 90 per cent. of manufacturers cordially desire to comply with their regulations. This is, of course, as it should be, but what manufacturers want to see is about 90 per cent. of such commissions agree among themselves and if this can be accomplished, more nearly 100 per cent. of manufacturers instead of only 90 per cent. will agree with them.

Surely the lumens are no different out in Wisconsin from what they are in New York, or even in Massachusetts, nor should the requirements for good lighting be any different, and it ought accordingly to be quite possible to get the American Engineering Societies' Standards Committee, in conjunction with the Bureau of Standards at Washington, to formulate a single "League of Nations" code for general use throughout the country, and this without any state losing its sovereign rights.

It is certainly pitiful to see a great big nation like this which prides itself on its breadth of view, its vision, and on its being in the front rank of every forward movement, wasting such vast amounts, both in time and money, in having its work done piecemeal, the same problems solved, the same duties duplicated in various parts of its domain, as is evidenced in so many ways, for example, by our State laws including the safety codes. Through the efforts of the American Society of Mechanical Engineers, we have secured a Boiler Code which bids fair to become universal, so why can we not corral these lighting codes, which are commencing to be turned loose and turn them into one code for the community at large?

Referring to the Pennsylvania code, as published, and with which the speaker is best acquainted, the preamble starts off with paragraph entitled "Petitions" showing how to proceed in case one desired to appeal from any of its provisions. The one appeal the speaker would make, as already pointed out, and in so doing he believes he pleads for many others, is "O Lord, deliver us from all State codes." He speaks the more feelingly in this case because immediately under the paragraph on "Petitions," is one

entitled "Penalties," with fines and imprisonment staring you in the face. Having been duly warned as to the consequences impending for violation of the code or failure to carry it out, there follows a paragraph entitled "Application," which, for literary fog, can hardly be surpassed. It reads, "All Safety Standards of the Industrial Board in force at the adoption of this Standard, or adopted after this Standard, applicable in any way to the Lighting Industry (What is the Lighting Industry, by the way?) or the operation of the Lighting Industry, or to the apparatus used in or around (how large a radius is included in 'around,') or in connection with the Lighting Industry, shall be considered as applying to the Lighting Industry, and to such operation and apparatus." It is quite clear from this (and it is the only clear thing about it), and taken in connection with the penalties, where most of those having anything to do with industrial lighting in Pennsylvania, are going to land.

The code itself is short as far as its technical side is concerned and the appendix contains some very good matter.

It is apparent from the wording that effort has been made to allow as much latitude as possible in the matter of intensities, elimination of glare, and spacing of lamps. As pointed out by Mr. Stickney, this is due to the fact that suitable values have not been determined which will accomplish the desired end without working unnecessary hardships on those chiefly concerned.

Under the paragraph on "Intensities Required" is given a table of the minimum as well as the desirable intensities required for different situations and classes of work. Mr. Stickney states that "every effort has been made to simplify the rules and make them understandable to other than engineers;" but, it has been the speaker's observation that illuminating engineers have apparently been recommending values for factory lighting altogether too low, based largely no doubt on a lack of knowledge of actual working conditions; for example, it takes as good light to read a micrometer, a finely divided rule, or a blue print, in the shop, as it does to read a slide rule or a tracing in the office. Therefore, even if the work be classed as rough, but involves the doing of such things as have been enumerated, then the lighting should be arranged on a higher base than the work itself would seem to require. Again, the loss of light from dirty and old lamps and reflectors is

glossed over too briefly, and the novice usually has to learn by more or less costly experience that in order to maintain the proper degree of illumination he must allow a wide margin over and above the values set down in tables.

The paragraph dealing with "Shading of Lamps" gives no idea of what may be considered as "Glare" or the value of a "minimum of glare." It is a matter of common knowledge that a light source of high intrinsic brilliancy within the range of vision not only prevents comfortable and accurate vision but may cause permanent injury to the eye if allowed to continue any length of time. The eye, due to the position of the sun at its maximum intensity, has become accustomed to bright light from overhead, yet the retinal fatigue resulting from snow underfoot on a bright winter day is sufficient evidence of its weakness in this respect. When lamps are mounted sufficiently high, the shading of the lights is not important except to distribute it properly, but when the mounting height is lowered this feature is one of very great importance, and the paragraph in question should accordingly be given more consideration than some of the other sections which have possibly been over-emphasized.

Still, again, the paragraph entitled "Distribution of Light on Work" reads "Lamps shall be so installed as regards to height, spacing, reflectors or other accessories, as to secure a good distribution of light on the work, avoiding objectionable shadows and sharp contrasts of intensity." This taken in conjunction with the intensities given in the tables, would seem to compel the use of overhead lighting exclusively and thus to eliminate localized lighting, whereas, much shop work is of such nature that anything short of individual lamps will prove quite unsatisfactory.

If the paragraph relating to emergency lighting, not only in the Pennsylvania but in the New Jersey code, really means what it says, namely, that every establishment where workers are employed, regardless of what it is, where or how built, or for what purpose it is used, must be equipped with two entirely independent systems of lighting, then we may as well expect to have incorporated in due course in this, that, or the other code, a provision that all machine tools shall have an extra base, that all tables and seats shall have extra sets of legs, that all buildings shall have an extra foundation, except of course in Wisconsin, where no foun-

dation at all will be permitted, since the lighting code in that remarkable state distinctly says every room must have daylight.

Again, a literal interpretation of the Pennsylvania Code would imply that an emergency system should provide an intensity equal to that of the regular system with an equal number of lamps used. The other extreme would be to furnish an emergency lamp merely as a marker in each working space, aisle, or exit, according to the custom in theatres and public buildings—to serve as a guide rather than to provide illumination. While the latter would prove somewhat inadequate, a duplicate system would be quite unnecessary. It would seem that a rather low intensity, such as that specified for yards and roadways, should satisfy every requirement for emergency lighting.

The code further requires that emergency lights shall operate concurrently with the regular system, meaning presumably that the emergency lights must be automatically turned on whenever the regular system is in general use. This would be unreasonably burdensome in a great many cases where plants are already wired and equipped for adequate ordinary lighting, without provision for concurrent and independent emergency lighting, and would involve the use of considerable power unnecessarily. Such plants would be compelled not only to rewire their buildings with separate emergency circuits, but to increase their lighting load and equipment beyond those limits which they have already found to give satisfactory illumination. In some classes of service where emergency lights are really necessary, it has been customary to control such circuits by relays actuated by the regular circuit; the relay operating and causing the emergency circuit to be lighted when, for any reason, the operation of the regular circuit is interrupted. This feature avoids the need of using power simultaneously and unnecessarily in the emergency circuit. The reliability of the emergency circuit may be insured by periodical tests, just as fire alarm boxes and equipment are inspected and tested.

Such a radical requirement as "Emergency Lighting" should, it seems to the speaker, certainly be made advisory rather than mandatory, at least until the various states shall have agreed upon a plan which has proven itself by actual experience to be feasible.

M. G. LLOYD: The author of the paper made a reference to the work of the Federal Safety Engineers, and perhaps a word in explanation of that would be of interest. The country had not been long in the war before the Government officials recognized the necessity of conserving human resources. In the summer of 1917, through the initiative of the U. S. Employees' Compensation Commission, there was started a survey of the conditions with respect to safety in the Government war plants, that is to say, the arsenals and the navy yards. As a result of the conditions disclosed in that survey it was decided to appoint safety engineers at each one of these plants, and that was done. The safety engineers, soon after their appointment, arranged a series of meetings at which they got together and drafted some rules to be enforced in their respective plants, with the idea of preventing accidents. Before they got very far along in this work they called upon the Bureau of Standards to assist them in drawing up these rules and codifying them, and in that way the Bureau took a hand in the work and in conjunction with them drafted a series of Federal safety standards which were utilized at these plants

Had the war continued longer than it did, it is probable that an attempt would have been made to have these safety standards applied to a larger field, that is to say, in munitions plants operated by private companies. The obvious method of securing such enforcement in plants not directly controlled by the Government would have been through the incorporation in Government contracts of proper clauses requiring conformity with the safety rules. With the war ending as it did, the matter, of course, was not pressed further.

The requirements for lighting which were incorporated in these safety standards were included in a set of Standards for Building Construction. These Federal Safety Standards have never been printed as yet. They were simply gotten out in mimeograph form for distribution among the Federal Safety Engineers for their own use and for the use of contractors supplying equipment for the use of the Government who had to conform with certain of the requirements of these rules. In these Federal Lighting Standards the code of the Illuminating Engineering Society was closely followed, but there were one or two items that were somewhat

different. The author has referred to the introduction of the requirement for a half-footcandle in the codes of New York and Wisconsin for certain places, such as toilets and wash rooms, and that provision was put in these Federal standards over a year ago, and that intensity was also applied to elevators and elevator landings, an item which has not been included in the Wisconsin code.

There was also a requirement covering daylight illumination as well as the artificial lighting, and there is a paragraph I want to call attention to, on account of Mr. Auel's remarks with regard to the effect of dirt, which rapidly decreases the illumination intensities, if it is not taken care of. That clause I might read, as follows: "Artificial lighting equipment and windows shall be periodically cleaned and kept in order so that the illumination intensities do not fall below the minimum value specified. Artificial lighting equipment shall be so installed as to be readily accessible for cleaning." It is recognized that that is a very important item in obtaining suitable values of illumination.

After these Federal Standards were completed we found that there was considerable demand from the outside for copies of them, showing that there are many persons who want some guide to follow for safe practices in private plants. As has already been mentioned this evening, there are many employers who have to be forced to provide suitable conditions, but there are many others who are always seeking information as to how they can better the conditions in their plants.

As a result of this demand it was concluded at the Bureau of Standards that it would be desirable for us to proceed to elaborate these Federal Standards so as to make them more complete and a more suitable series of codes for general use We have started that work, which has been referred to by our presiding officer, and have four national industrial safety codes now under way.

In considering the requirements in the different industries from the safety standpoint, it may be desirable to know what suitable illumination intensities would apply in the different industries, and I am consequently very much interested in the attempts that have been made in New York State and in Ohio to determine the suitable values in separate individual industries. I hope to see considerably more work done in that direction.

Another point where lighting standards touch the work of the Bureau of Standards is in the National Electrical Safety Code, which has been worked upon at the Bureau for a number of years, and of which a tentative edition for trial application has been in print for over two years. We are now engaged in revising that code and attempting to make it more complete and improving the provisions wherever possible. The present edition of the National Electrical Safety Code has some rather general requirements for illumination. For instance, with reference to generating stations and substations, there is a requirement for an emergency source of illumination, as it is one of the places where it is considered necessary that complete darkness should not result from any disturbance with the usual lighting system. An exception is made to that requirement in the case of automatic substations, which are, of course, in condition to operate without an attendant.

There are certain limitations to illumination in storage-battery rooms. For instance, there is a requirement that sockets in that location shall be of the keyless variety, with the idea of preventing any spark which might ignite hydrogen gas and cause an explosion, since such gas is liable to be present in a room of that description. The requirements, however, for intensities of illumination are not very definite; they are covered by such terms as "good" or "sufficient" or "adequate." In the next edition of the Code we hope to get information which will guide those responsible for providing suitable illumination in that class of rooms. We called upon the Illuminating Engineering Society for help in this connection, and I want to express our appreciation of the co-operation which we have received. A committee of the Society carried out an investigation and has made a report giving some values of illumination which they consider suitable requirements to insure safety in such situations. They have recommended, as usual, a minimum requirement and given also a value representing what is considered good modern practice.

I might call attention to the fact also, in view of Mr. Auel's comment, that in the Electrical Safety Code there is provided a set of operating rules which the employee is required to follow in his work in order to do his share in avoiding possible accidents.

ILLUMINATION VALUES FOR POWER PLANTS.

Approved by the Council of the Illuminating Engineering Society, November 4, 1918.

	Minimum Foot-candles	Modern practice Foot-candles
Switchboard instruments, gauges, switches, etc...	1	2 to 4
Switchboards with no exposed live parts.......	½	1 to 2
Storage battery room	½	1 to 2
Generating room, boiler room, pump room (at machinery or exposed live parts)...........	1	2 to 4
Stairways and passageways (measurements made at floor level)	½	1 to 2
Stairways and passageways (measurements made at floor level) where there is moving machinery, exposed live parts, hot pipes, etc........	1	2 to 4

The illumination values to be those for the working surfaces. (Measurements to be made on the vertical, horizontal or intermediate plane, as the case may be.)

Any traversed space to be illuminated to not less than one-quarter of a foot-candle minimum (measured at floor level).

Before closing, I want to mention the Oregon law, to which the author referred, and a copy of which I have. This law, as he mentioned, does not include any definite quantitative values for illumination, but confers upon the Commissioner of Labor the duty of specifying them. It makes general requirements that places shall be adequately and properly lighted; it covers requirements to minimize glare; it provides for suitable distribution of the light, and has a requirement for emergency lamps. There is also the usual requirement for the control of the lighting system. There is a rather unusual provision, however, in empowering the Commissioner of Labor to specify the minimum intensity. This section of the law states that the Commissioner is authorized to establish minimum values. It then goes on to say that he shall be guided in so doing by the recommendations of the Illuminating Engineering Society, but before the specified values can become effective, he is required on his own initiative to appoint a commission of three persons, one to represent manufacturing interests, one to represent electrical workers, and one to be an electrical engineer. This Commission is to hold hearings and it is expressly stated that this Commission shall have power, independently of the Commissioner of Labor, to establish, rearrange or readjust the schedule of limiting values and rules

as above set forth, that is, as designated by the Commissioner himself; in other words, there is a court of review, we might say, provided to approve or amend the schedule provided by the Commissioner of Labor, supposedly with the recommendation of the Illuminating Engineering Society.

There is one other point about the Oregon law that seems to me rather important. Most of the State commissions which have acted in regard to the lighting code have general powers for making requirements along the line of safety for factory workers. In the case of Oregon, however, this is a particular separate law, conferring this power on the Commissioner of Labor, to make these requirements. It is of interest to observe that in this law there is no reference to safety, and that apparently the Commissioner is given powers to determine minimum values upon any basis that he may consider fit, not necessarily upon the safety basis. That would seem to open the way for him to make requirements which would be higher than would be ordinarily deemed sufficient merely to provide safety.

WARD HARRISON: I do not believe any of us fail to sympathize with Mr. Auel's view that he would like to see a National Code covering the whole subject. At the same time, I think he will acknowledge that the situation as far as the Lighting Code is concerned, is far better than in the case of the tax laws, or almost any other kind of State legislation with which he may be familiar. Then too, as Mr. Stickney has said, there would be an emphatic dissent at the present time from any intimation that we knew all about lighting, and just how universal and permanent legislation on the subject should be framed. There are a great many things that we do not know. The various states in the supplements to their respective codes—most of the differences in the codes are in the supplemental matter—can try out different plans and thus find which one works most equitably and effectively. We shall make more progress in this way than if all were exactly uniform from the beginning.

When the subject of lighting codes was first proposed in some states the attitude of a number of large employers was that of opposition. I know of one case where they said, "We have competent engineers to take care of our lighting; let the other fellow

do likewise. This Code will be nothing but one more law added on to all the rest of the industrial regulations. Why should we further it?" At this point one of his associates from another plant replied, "We must not forget that the interests of the large and small manufacturer, so far as labor is concerned, are identical. It is possible that your plant is so well lighted throughout that the eye-sight of your workers will never be impaired and that no accidents will happen attributable to this cause. Yet, you must not forget that the entire community is your labor supply. If the small plants are poorly lighted and if as a result of that there are maimed workers or workers with impaired vision, these men, when in the course of time they go to work in the larger plant, will certainly reduce your average efficiency. We are in favor of having all plants in this state properly lighted."

On the general question of lighting intensities it might be said that, up to this time we have been for the most part in the same condition in which people found themselves a century or more ago in regard to heating. Then they were dependent upon open fires, and temperature-measuring instruments were a rarity. If you stood close to that fire it almost burned you up and yet other portions of the room were often below 40° F. Very nearly the same effect is had in lighting by the use of bare drop lamps with no general illumination.

At the time thermometers came into general use people not only began to appreciate what the temperature variations were, but to demand temperatures all over the house which were comfortable; the footcandle meter and similar measuring instruments should likewise lead to the same conception of lighting intensities. Unfortunately, we have no satisfactory instrument for measuring glare, as yet; in fact, as the author has stated, we do not know just what we want to measure. However, decided progress is being made along these lines and in two or three years we may well expect some form of glare meter which will measure glare almost as readily as the footcandle meter measures illumination. When this is accomplished we shall be more nearly ready for a national code.

JOHN VOGT: In New York State we have a code which we think is about as good as any, and this evening we have not re-

ceived as many knocks as some of the other states. I believe if these other states had conferred upon the different Departments of Labor, Law or rule making power there would be more uniform codes promulgated.

Back in 1897 the labor law of New York State contained provisions for proper lighting of factories and the proper lighting of aisles, stairways and stair halls. In 1903 provisions were added to provide for adequate light in basements and mercantile establishments where women and children were employed. In 1912 and 1913 forty-six sections were added to the labor law as a result of an investigation by the State Factory Commission and gave authority to the Industrial Board of the Labor Department to make suitable regulations as to standards for temperature, ventilation, lighting, etc. About two years ago the Industrial Committee on Lighting was formed and we got up this code to regulate the lighting of factories. Many sections of the labor law relate to the proper, sufficient and adequate lighting of stairs, stair halls, stairways, workrooms, storerooms, elevator entrances, elevator cars, washrooms, toilet rooms, etc. These words "sufficient, proper and adequate" meant nothing to the ordinary inspector who is called upon to enforce the provisions of the law. In those intensities which we have worked out we thought it best to follow the Illuminating Engineering Society's Code, and in addition thereto to make a large number of photometric tests ourselves. We have a corps of engineers in the department which is capable of doing this kind of work, and more than ten thousand lighting tests were made for the Code Committee. Since then, there have been more than five thousand tests made, so that these tests play a very important part on the amount of light which is specified in our Code.

One thing that interested me in this paper was relative to the education of inspectors and the suggestion that the inspectors might not be able to carry out the work. Our inspectors are regularly drilled, regularly given lectures. Every two weeks inspectors of our department are called together, and have been for the last three months in the Metropolitan Hall, and given lectures in connection with the American Museum of Safety in matters of this kind. We have particularly given four or five lectures to the factory inspectors from the practical standpoint

of our law, not alone on illumination, but sanitation and safety, the removal of dust, fumes and gas. We realize that the Code as it stands to-day is embryonic. It is partly mandatory, but not mandatory insofar as other hearings to be held in the various states, relative to the amounts of light to be provided at processes of manufacture are concerned.

To give you some idea what the department has done in the past year as to orders issued and compliances secured in the regular work of the Department, I have gone over the statistics and find that during the month of July, 1918, when the Code went into effect, relative to that part which is mandatory, that is, the intensities required in washrooms, toilet rooms, aisles, passageways, storerooms, etc., leaving out the part which will be mandatory after July 1, 1919, after the hearings are held at which manufacturers are invited and other express their opinion at these hearings, which are to be held in the cities of Buffalo, Rochester, Utica, New York and some other points, as to whether we are right or not, or whether the Code is proper, the inspectors issued during July 105 orders relating to lights and secured three compliances; in August of 1918, 135 orders issued and 67 compliances secured; September, 174 orders issued and 278 compliances secured; October, 64 orders issued and 88 compliances secured; November, 546 orders issued and 156 compliances secured; December, 446 orders issued and 205 compliances secured; January, 1919, 608 orders issued and 517 compliances secured; February, 765 orders issued and 50 compliances secured, a total of 3,290 light orders issued and 1,569 compliances secured, and only 92 waivers made. These statistics include the work only up to March 1st. Our statistics are not ready for the later months. These orders were issued out of a total of 56,236 inspections of the regular type and 4,791 special inspections. This gives you some idea as to the character of work and the quantity of work that the Department of Labor, now the Industrial Commission, has done.

Total orders issued up to March 1st, 3,290 and compliances secured, 1,569, that is, about twice the number of orders issued as compliances secured, giving about 1,500 or 1,600 compliances still to be secured. I have not had time to segregate these orders to determine whether they were for glare or for improper dis-

tribution, etc. From what I can remember, most of them were for the elimination of glare or minimizing of glare.

Many other orders have since been secured, no doubt, but I have only given statistics up to the 1st of March. These orders go out, and the parties upon whom they are served are given a definite time in which to comply with the law. Manufacturers may ask for an extension of time. In that case the order still is pending. In the case of all orders that are pending, compliance will be insisted upon, and if the ordinary method does not secure it the Court will be resorted to. We have a capable legal bureau and these things are threshed out in Court if necessary.

W. P. Hurley: It seems to me that if the codes in themselves are in advance of the popular education, it is the work of the promotion of these codes that needs to be taken in hand, in order to make them of the greatest efficiency. We may get ourselves into the position of the states of Wisconsin and Massachusetts, with their insurance laws, where they passed useful and effective laws, providing for state insurance, but they fell flat because the popular education was not sufficiently advanced on the subject for the people to make use of them.

One of the most interesting points, that has not been touched on here to-night, is how to bring these codes before the public, and it seems to me we must first appeal to the self-interest of the user, that is, the manufacturer, and next the self-interest of those who can with profit to themselves bring the codes to the attention of those manufacturers, and keep up this education, otherwise the burden must be on the Society as a scientific body, and on the Labor Bureaus of the different states. Even if the different states handle it, it means the popular education of the users, and this work will have to be undertaken by them. It would mean that the inspectors, even, must be educated to tell when the law is violated, and they would have to organize to the extent of telling the men how to design installations, which is usually considered beyond their province.

The present time is particularly ripe for the education of all the interests concerned in the lighting industry—by that I mean the manufacturers of the incandescent lamps and the fixtures and the wiring contractors, as well as the plant departments

themselves of these manufacturers. It is particularly suitable at this time because we have the gas filled lamp practically in its infancy, as far as application is concerned. The educational work should be with the contractors and dealers. This would be found to react at once in favor of the Code, because it would give them a legal standing and something to work by that could be published and made use of.

W. T. BLACKWELL: This subject has been considered from practically every phase but there is one point which I would like to bring up and that is the instrumentality through which we are to enforce the code. We have at the present time codes in four or five states, therefore, we must take into consideration how the lighting measures in the codes are to be enforced. The Department of Labor Inspectors, upon whom it is encumbent to enforce the requirements of the codes, are as a rule appointed through Civil Service examinations. We as a Society have fathered these codes—therefore, we should take the initiative in taking measures toward the end that the inspectors may receive proper information which will enable them to do their work properly. Last year a series of lectures were arranged at the University of Pennsylvania, under Professor Clewell, for the training of the inspectors of the States of Pennsylvania and New Jersey. Owing to the short period covered by these lectures only a meager idea of the requirements of good lighting could be touched upon.

Many of the codes have a monetary penalty for non-compliance with its requirements and in consequence an inspector who is not thoroughly familiar with lighting is therefore not in a position to determine whether the prevailing conditions in a plant come within the minimum requirements of the code and therefore hesitates about placing a violation on the installation. It seems to me that having evolved the code we should bend our efforts toward the education of the inspectors as has been suggested by the previous speakers. This perhaps can best be done by placing in the hands of the inspectors some form of a manual which would be comparable to the National Electrical Code or the Fire Prevention Manual adopted by the National Board of Fire Underwriters, and also the National Fire Prevention Bureau.

The foot-candle meter provides a ready means of checking up the intensities of illumination, provided the inspections are made at night, but if the inspector is to use this instrument for measuring daylight intensities it will then be necessary to have the instrument equipped with a daylight screen. This, of course, does not offer an insurmountable obstacle but it occurs to me that this instrument offers the best solution to settling differences of opinion which may arise between the inspector and the superintendent of a plant. It would, therefore, seem desirable that the use of foot-candle meters properly fitted to the requirements of the situation should be encouraged in those states where codes are in force.

In order to thoroughly understand the situation and the conditions under which such inspectors work, we must place ourselves in their position or otherwise I fear that the lighting legislation now incorporated in the Labor Codes of several states will become inoperative through lack of enforcement. I, therefore, hope that the Society will take some measures toward formulating an inspection manual for the use of the inspectors in those states having codes.

E. G. PERROTT: A point in connection with the Code which I think should be amplified, is the question whether the minimum of illumination should be stated in the Code, or whether it should be left to the discretion of the Labor Department, or the Commissioner who enforces the code.

I wish to mention something which might be considered as paralleling in its operation the lighting codes, that is, the building codes of the various cities. We have in Philadelphia a Building Code under which we are suffering, due to the fact it was adopted in 1854, while it was suitable for that period, from the standpoint of the knowledge which existed at that time, whereas the knowledge of building construction has advanced to such an extent that it no longer applies. The law is a State law and cannot be changed by local authority, cannot be changed by anybody that has anything to do with building construction, and as it requires State action, it is a very difficult matter to get the State Legislature to repeal old acts and reframe them to suit new conditions.

It appears to me that in the state of the art as it is to-day we are in a much better position if we omit from the Code itself the actual illumination we desire for the various parts of the building and leave it to the commissions or to the labor departments to establish as has been done, I believe, in the state of Oregon, which it seems to me is a better way.

DISCUSSION AT CHICAGO.

John A. Hoeveler: Mr. Stickney's discussion of glare limit specifications should receive more than a cursory reading. The elimination of glare in artificial lighting is a vital matter. Whether or not a lighting system is to properly fulfil its function depends more, or at least as much, upon the elimination of bad glare as upon the intensity of illumination at the work.

To properly formulate a glare specification we must definitely keep in mind just what we mean by glare. The Illuminating Engineering Society has defined glare as "any brightness within the field of vision of such a character as to cause discomfort, annoyance, interference with vision, or eye fatigue." Moreover, we must make some observations regarding what constitute the conditions that make up glare as above defined. I believe it is now quite generally accepted that glare from lamps is dependent upon:

(1) Brightness of light source.
(2) Contrasts of brightness.
(3) Intensity of light entering the eye.
(4) Angle at which light enters the eye.

Any complete glare rule, therefore, must take into consideration all four of these items. The present Wisconsin rule attempts to regulate items 1, 3 and 4, but item 2 is not covered by the rule. Since the policy of the Commission is to recommend that lamps be placed as high as practicable and that the upper walls and ceiling be finished in light shades, it is hoped that brightness contrasts will be kept down, and glare from this cause minimized.

The limit of 75 candlepower for the brightest square inch of visible light source undoubtedly is high, and as soon as a proper maximum value can be set by the Illuminating Engineering Society it should be revised. The fact has also been recognized by the Commission that lamps suspended at high elevations, even

if they come within the specified glare angle, cause less glare than lamps at low elevation, and therefore, lamps elevated 20 feet above the floor are excepted from the rule.

A revision of this glare rule along the lines hinted at in note (*b*), I think will require the attention of the Commission at some future date, because it is essential that some provision be made to minimize glare due to specular reflection from polished surfaces worked upon. This revision was given consideration at the time the code was being drafted, but since its enforcement would require all tungsten lamps to be bowl-frosted, opaled or provided with shielding accessories, it was deemed advisable to postpone this requirement until some of the worst evils of present day lighting are corrected.

In placing the code before the employers of Wisconsin, I have them fully understand that the requirements set forth in the code are only the minimum which will sufficiently safeguard the safety and health of the employees. I have them understand that in practically all cases the industrial manager will find it highly profitable to provide materially better lighting than that which will barely meet the requirements of the code. Therefore, the excellent work which Mr. William A. Durgin, of the Commonwealth Edison Company, of Chicago, is doing in the way of practically demonstrating that the employer can make marked gains in production by providing better illumination, is of immense value. It is this kind of information which is convincing to the plant manager. I further attempt to impress upon the manager that providing a sufficient quantity of illumination upon the work is but part of the problem; that it is of equally great importance to secure proper quality of light, proper direction of light on the work, freedom from objectionable shadows and screen conditions not suitable for the eye to perform its functions without excessive fatigue.

At the present time the Industrial Lighting Code applies to new construction, only. All plans for new factories, additions or reconstruction must be submitted to the Industrial Commission for approval before construction may be started. I mean to say "approval" in so far as the provisions of the Building Code are concerned. Lighting plans need not be submitted. However, when these plans come into the office, they are carefully scruti-

nized as to the provisions made for natural lighting, and the employers are advised in a general way regarding desirable artificial lighting. Of course this advice can only cover the broad outlines of the problem. For detailed designs of the artificial lighting, the Industrial Commission advises the employers to secure the services of an illuminating engineer, or if the factory manager personally undertakes to decide as to the lighting system to be employed, or if he places this responsibility upon his electrical department, the Industrial Commission recommends that he avail himself of such commercial services as are usually supplied by the local central station, first-class electrical contractors or reliable manufacturers of lighting equipment.

The Wisconsin Code was drafted by an Advisory Committee representing the various industries affected. The personnel was as follows: Four illuminating engineers representing the United States Public Health Service; the city of Milwaukee; a central station and the Industrial Commission, respectively; a factory electrician; a factory works manager; an electrical contractor; the manager of a gas light company and an oculist. This committee consulted other authorities, such as the Illuminating Engineering Society and the Labor Departments of other states. After it made its recommendations, the proposed code was subjected to a public hearing and then adopted by the Commission, and published. Now the advantage of having a code drafted by a committee representing the various industries affected, is that the Commission thereby secures the active co-operation of all concerned, and voluntary compliance on the part of a large number of employers. Moreover, objectors to the code are more readily satisfied as to its reasonableness if they see that it has been prepared by employers themselves, not by the Commission.

The Wisconsin Code has an order which makes mandatory proper maintenance of the lighting system. It has been suggested by some that this order is superfluous, inasmuch as strict compliance with the other orders would insure adequate maintenance. This is true, but the Commission felt that a specific order directed at proper maintenance would make the work of the inspector easier. Without further explanation he can cite this order and require proper repairs and cleaning of equipment when he finds defective equipment in use.

F. H. BERNHARD: In this very room a few weeks ago, at a meeting to consider legislation pending before the Illinois Legislature of interest to engineers, one of the senators of that body said he believed the state would be better off, if the Legislature met but once in ten years instead of every two years. This shows that even legislators recognize that of the great mass of our statutes there is a very large percentage that is not enforced nor is enforcible and which had better never been enacted. In proposing legislation covering the factory lighting, it is, therefore, necessary to proceed with great care, lest on the other hand, we add to the present superfluity of laws or, on the other, we let matter drift to the detriment of the safety and vision of countless factory employees.

Mr. Stickney's admirable review of the existing industrial lighting codes shows that these have been wisely drafted along an intermediate course. They provide quite readily defined and easily enforcible regulations to insure safety and eyesight, as far as these are affected by lighting. They avoid the meaningless ambiguities and impractical requirements found in many headlight laws and ordinances, for example, which are on this account practically dead letters. Instead, they lay down simple rules and only to the extent that is now warranted by the developments in illuminating engineering, and they leave these to be modified as further progress in the science and art may indicate as most desirable. From this it must be concluded that these lighting codes constitute wholesome and necessary requirements that it is to be hoped will be put into effect as soon as possible in every industrial state

DONALD BOWMAN: Mr. Stickney referred to the subject of emergency lights in his paper. Where a storage battery or gas is available it is easy to provide a source for emergency lights in installations which are normally supplied from alternating current. I would like to know what means of supply for emergency lights in installations where alternating current only is available.

E. D. TILLSON: Mr. Stickney has referred to the possibilities of the foot-candle meter, as a means toward acquainting the public with the unit of measurement of illumination, namely, the

foot-candle. He has drawn a comparison between this instrument and the thermometer which allows the least informed to instantly evaluate room temperatures, and through which the public has come to know, to judge, and to control heat or cold with an ease and accuracy almost unknown in other fields.

Such a consummation in the lighting realm would no doubt mean more to the cause of good illumination than any other knowledge that might be imparted to the lay public.

For example, the heating and ventilating engineer provides radiation sufficient to secure an even room temperature of 68° or 70° F.

Or, the power engineer, knowing the exact power requirements of individual machines; transmission losses, diversity factors to be expected, etc., provides a motor, or motors that will, economically and fully handle the power load.

In neither of these cases does the engineer use guess work, nor does he expect his recommendations to be cut down to one-half, or one-quarter of what he has stipulated.

On the other hand, when it comes to lighting these same buildings, does the contractor, or "sales engineer" provide a "nice soft light," neither the owner, contractor or salesman knowing even the average foot-candle illumination that will be created by the equipment.

Or how often does the qualified engineer carefully lay out the lighting system, intended to furnish a certain definite average illumination, and then have his recommendations cut to one-half or one-quarter by the owner or some advisor, who says "give me one light here, and one there, that's all I need right now."

To put the matter on a fact and figure basis, and eliminate so far as possible, the loose phraseology and vague conceptions that have so generally accompanied the sale of lighting, the Commonwealth Edison Company has, during the last year, written an explanatory letter to each prospective industrial customer. This letter accompanied the proposal for wiring, fixtures, etc.

The letter states the existing illumination in foot-candles (where there is already artificial lighting), the watts per square foot watts per employee, effective lumens per watt, and other figures.

These statements are made in as clear a manner as feasible, and the datum is interspersed with other matter in such a way as to make the reader "sit up in his chair" if possible.

It is recognized that the terms are a foreign language to the average customer, but they are given in every letter nevertheless, with the idea that ultimately there will be developed a dim comprehension that illumination involves more than selling fixtures to give a "nice soft light."

But returning to the foot-candle meter. There are two radical differences between it and the thermometer; first, the price. Any man can go to a nearby store and purchase a good thermometer for thirty-five cents; but he must pay $25 for a foot-candle meter.

It is natural to ask, how widespread would the use of the thermometer be, if the price were $25? Or, can the foot-candle meters come into universal employ under such a handicap?

Second: The thermometer is ordinarily used as a stationary instrument, while the foot-candle meter is a portable outfit.

The Commonwealth Edison laboratory recently had occasion to make up an exaggerated model of a foot-candle meter, and used therefore, a 10-watt, 115-volt Mazda lamp, placed at the end of a suitable box perforated in imitation of the regular instrument.

With the lamp plugged into the regular down-town direct current supply, and with a few minor adjustments, it was surprising how nearly this model checked with a recently purchased foot-candle meter. The model was built in an hour or so, and the cost was in the neighborhood of $2.00.

This led Mr. R. M. Graves of the laboratory to suggest that a low-priced instrument might be commercialized, similar, for example, to a dental lamp with series resistance, or possibly a 10-watt, 115 volt lamp, in either case the filament to be fairly concentrated and located at one end of the bulb, which should preferably be long and slender as in the "bung hole" lamp (T-8, 12-inch tubular). The bulb could be given an opaque coating except for graduated perforations occurring throughout its length.

Such a device, in size and appearance not unlike a thermometer, could be furnished with 10 or 15 feet of cord, and a number of them might be permanently plugged in at various points through-

out a factory, store or office building. Their object and use, because of the stationary character of the instrument, would become familiar to many, and the unit of measurement, *i. e.*, the foot-candle, on which it was based, would become a homely term to a large number.

With such a device, falling illumination due to deterioration, outages, etc., would be immediately disclosed, and a constant check and corrective placed at hand against the thousand and one mal-practices that often, within a few months, drag a perfectly virtuous new lighting installation into the mire.

DISCUSSION AT BOSTON.

DR. LOUIS BELL: From a practical standpoint most of the regulations of the codes now in force are of a character to appeal directly to the common sense manufacturer when brought to his attention. It is not difficult to show that bad lighting means poor work, and poor work does not pay. The main thing seems to be to have a sufficiently vigorous enforcement of the code to bring it immediately into notice, and to shake out of their bad habits of long standing some of the manufacturers who are slow to appreciate the economic facts. Practically it strikes me that the least satisfactory part of the usual codes lies in the matter of emergency lighting, especially in small and medium sized factories. In a large plant the provisions requiring a virtually independent system of emergency lights can be met without any particular difficulty. Special new construction for emergency lighting from a separate source can easily be made a useful though independent part of the general illumination. In comparatively small manufacturing establishments, however, the case is different. Only a few lights may be required to meet the full illumination provisions of the code and a separate circuit to the street main becomes a somewhat burdensome provision. This is especially true in many old buildings occupied by a variety of small industries, in any one of which only a few workmen are employed and a small number of lights needed. To get an independent source in any proper sense of the word requires often a large amount of new wiring, perhaps going all through the building. In such cases, too, the independent lighting passages and stair-

ways becomes closely connected with the matter of emergency lights and lights just inside the entrance of work rooms. The present code regulations on the subject are somewhat vague. Certainly a little machine shop perhaps 20 feet square and employing four or five men does not require an emergency lighting system in the same sense that it is necessary in a large work space with many employees. I am inclined to think that while Commissions must necessarily have considerable latitude in matters of this kind, it would be well to consider the limitation of the independent emergency light requirement in terms of space occupied or number of employees, or both, so as to relieve in a measure the necessity of inspectors depending entirely on their individual judgments as to whether the code as it stands should be enforced. Some such qualification would seem to be desirable, also, on account of the somewhat varying understandings as to what is legally meant by a factory or work room in various jurisdictions.

J. W. Cowles: It is gratifying to note throughout Mr. Stickney's paper as well as in the lighting codes formulated by the various states a very evident desire to keep within reasonable and practicable limits in specifying requirements covering different lighting conditions.

Furthermore, it would seem a very wise procedure to follow the practice of specifying limits subject to interpretation and application by inspectors as representatives of responsible commissions rather than to prescribe fixed and rigid rules in view of changes in the art and the progress still in making along the various lines of illumination.

While experience with inspectors, whether Governmental, municipal, or private, sometimes tends toward loss of confidence in the reliability of the human equation, experience in general is sufficient to show that reasonable results may be expected, and at least intelligent inspectors with discretionary authority are productive of better results than when inspectors are held to rigid interpretations with little or no discretionary powers.

In general the aims and intentions of these lighting codes are clearly in the public good, and, therefore, must be accepted as mutually beneficial to all concerned, assuming that they are going

to be developed and applied intelligently and gradually rather than by any drastic procedures.

One point, however, demands careful consideration in order to avoid unwarranted hardships, both to industrial and central station interests, *viz.*, "emergency lighting" requirements.

In some of the codes there appears to be quite a trend toward the so-called theatre requirements for emergency lighting, these requirements being very generally accepted to-day in connection with theatre and auditorium lighting. It must be recognized, however, that these theatre requirements involve a very considerable expense both to the customers and the supplying companies, and furthermore involve very considerable complications in metering and carrying out of commercial contract requirements.

So far as separation of interior wiring, even to the extent of separate service supply from the street may be justified in the interests of life and property protection, they must be accepted gracefully by all concerned, but any extension of such requirements to industrial conditions beyond the actual requirements of life protection must be looked upon with discouragement as involving unwarranted expense and complications both to the industry and the central station or other source of supply.

No doubt factory conditions may and do exist which involve nearly if not equally great risks as in theatre installations, and so far as this condition may be true, little exception can be taken to the application of protective and safety rules. Here, however, is where inexperienced or unreasonable inspectors might apply interpretations of the rule quite unwarranted by the actual conditions existing, thereby tending to make a lighting code very unpopular by those who should be foremost among its supporters in the interests of public good.

It is a fact that the trend of the past ten years toward stricter rules governing interior electric wiring have had a very marked effect in increasing the cost of building wiring, so much so as to become a serious obstacle in many cases.

While these modern requirements have all made for better and more durable construction, they have seriously interferred with the wiring of many buildings which would otherwise have become good electric service prospects. It would seem, therefore, that the emergency lighting rule in any code should be drawn with

particular care in order to avoid unwarranted application of the requirement for separation of wiring, metering and service supply.

From the central station standpoint I desire to urgently commend this section of the code for careful consideration and such framing as shall clearly set forth its real intention and as shall prevent its unwarranted application with resultant hardships to those concerned.

COMMUNICATED DISCUSSION.

T. F. Foltz, Mechanical Engineer, Pennsylvania Department of Labor and Industry: Although there has been a lighting code in force in the State of Pennsylvania for nearly three years, it is only during the past year that definite arrangements have been made by the Department of Labor and Industry to apply its requirements in more than an advisory way. This was due largely to war conditions which affected to a large extent the industries in this State and made difficult the detailing and training of inspectors for this work.

With the revision of the code about a year ago and the course of excellent lectures given to the inspectors last year at the University of Pennsylvania through the courtesy of Professor Clewell, the real work of applying the provisions of the code commenced. These lectures were supplemented by talks at inspectors' meetings of the different districts into which the state force of factory inspectors is divided. It soon became apparent, however, that it was more practicable to detail for this work, men who by training and aptitude, could be drilled into the work of judging and advising on good lighting arrangements for industrial plants. These men are being given special instructions on the subject of factory lighting and on the use of the recently developed compact and convenient foot-candle meter with which each man is equipped. Although the training of these men is not yet completed, results would indicate that we are on the right track.

Thus far it has seemed inadvisable to use the police powers to secure compliance with the provisions of the lighting code; the method used, therefore, is one rather of education and co-operation. It has been found that the average employer, especially the one who does not have a business big enough to have experts on his staff, knows little or nothing about good and bad lighting;

although experience shows that he is, on the whole, anxious to correct conditions when he is shown how to do so. He is conversant with requirements for machinery guarding, dust and fume removal, etc., and these requirements can be laid down in concrete form as to dimensions, materials, etc. To him, a requirement for a 5-foot guard is clear, but he has yet to learn the meaning of an illumination intensity of 3 foot-candles. As a means of educating the employer, there was issued with the last edition of our lighting code, an appendix containing much of the information in the Illuminating Engineering Society "Code of Lighting Factories, Mills and Other Work Places."

Some employers can be won over best by the money argument. When they are shown the ridiculously low cost of a good lighting system, as compared with the saving they can make in better and greater output, less spoilage, etc., they regard it as a shrewd business proposition to comply. The means of gaining compliance must be determined after a careful analysis of local conditions as the inspector will find them; and our experience would indicate that compliance with our requirements secured through cooperation and education produces more lasting results than that obtained by the exercising of mandatory powers.

A strict interpretation of the legislation which gives this department its authority would seem to limit its requirements to those just sufficient to prevent accidents to the workers. Illumination adequate for this purpose, obviously, is not enough for satisfactory and efficient work. However, those powers might be interpreted to include the authority to call for conditions that would reduce eye strain, industrial fatigue, etc. Such a broad interpretation, then, would permit requirements for lighting which would be sufficient, not only to prevent accidents, but also to result in truly adequate illumination for all purposes.

Mr. Stickney's paper is a most comprehensive analysis of this subject. He not only shows that considerable progress has been made on the subject of lighting legislation, but he also frankly admits that certain phases are still susceptible to much improvement. For instance, the subject of glare, an element most difficult of treatment in a code, is still in need of further study. To our mind the treatment of glare is as important, if not more so, than that of illumination intensities. It is futile to provide a

sufficient quantity of illumination unless the lights are so disposed and equipped as to minimize glare. The requirement that lamps under a height of 20 feet be specially equipped, does not begin to cover the case as there is nothing said about intrinsic brilliancy, size of unit, contrast of brightness, or whether or not the light source is within the field of vision. Limiting the candlepower per square inch of light source does not cover the case as a certain light source in a comparatively dark field may be objectionable, whereas, the same light source in a light field may not be annoying. Thus far, the California requirement takes into account the greatest number of factors affecting glare, particularly that referring to the light source being within field of vision. To cover the case adequately, a rule or formula would have to take into account the intrinsic brilliancy of the light source, contrast of brightness, distance and angle at which the light source is viewed, and the nature of the work done. It is obvious that the complexity of such a rule or formula would militate against its adoption. It is indeed unfortunate that some mechanical means to evaluate glare has not yet been developed to the extent that has the meter for measuring footcandle intensities.

No attempt is made in our code to give detailed requirements as to the extent and means of securing emergency lighting. Local condition will have to determine whether the emergency lighting will be from an independent lighting plant, separate transformers, separate fases, from a separate power circuit, or from gas or even oil lamps. The manufacturing processes and the nature and occupancy of the building are also determining factors. The inspector is compelled to exercise fine judgment after making a careful survey of local conditions.

Much credit is due the Illuminating Engineering Society and its individual members for the rapid progress recently made on the subject of lighting legislation, and it is noted with considerable satisfaction that they intend to make further progress along this line. The Pennsylvania Department of Labor and Industry will welcome developments that will increase the practicability of its lighting code.

James R. Cravath: Like other legislation, industrial code lighting legislation is largely a problem of education. First the

experts formulating such codes must thoroughly educate themselves on the conditions to be met. Next, they must pass this information along in usable form to the non-technical legislator and user. Before such codes become thoroughly effective, those responsible for the enforcement of the law must be educated as well as those upon whom the law must be enforced. Such education means that the factory inspectors and superintendents, operating under the law, must understand something of the illumination unit with which they are dealing. Fortunately simplification of instruments for measuring illumination has recently placed this matter on a much more satisfactory basis than heretofore, so that education in what a footcandle of illumination really means can be carried on a sufficiently large scale to accomplish the desired results within a reasonable time.

Specifications with regard to glare, as the author indicates are rather difficult to formulate at this time, when one considers the prime reason for such legislation is safety. As far as safety goes, lighting conditions are tolerable which would by no means come up to reasonable hygienic requirements. For example, a glaring light source may be far enough above the line of vision not to interfere with clearness of vision and so it would be exempt under any "safety first" regulations. However, it might be a very bad source of eye fatigue or strain. As this would pertain to the health of the workers, it would also be a justifiable subject of legislation even though not necessary for safety from accidents. The Wisconsin code, which as the author says, is the only one giving definite glare limit specifications, is nevertheless very lenient. Seventy-five candlepower per square inch is over 3,600 millilamberts or considerably brighter than an acetylene flame. The difficulty of formulating glare regulations is of course great. Our knowledge of what glare limitations are desirable is probably greater than our knowledge of how to lay down such limitation in a code which must take in such an infinite variety of conditions, as an industrial lighting code.

G. H. Stickney (In reply): The extensive discussion which this paper has evoked is a gratifying indication of the wide interest in the subject. The general unanimity of opinion expressed seems to indicate a remarkable agreement among engineers with the line of procedure. There is considerable opportunity for de-

bate as to how far certain specifications should go. I am convinced that more experience in applying the codes is the only reliable basis for determining these questions very much further.

We can all agree with President Adams that manufacturers should welcome safety provisions for humanitarian reasons, independent of ordinary factors of economy. While the Commissions have reported a broad attitude on the part of manufacturers, it is undoubtedly true that the enthusiastic acceptance of the codes by manufacturers will be encouraged by the realization that the codes make for economy rather than expense. Thus, the educational work in which Prof. Clewell and Dr. Rosa have expressed so much interest, will be even more important than might otherwise appear.

The whole trend of the discussion is to emphasize the need of wider popular education in regard to the factors of illumination. It would seem as if there were a need of going even further than anything which has been projected. We may well urge that the values and characteristics of light be taken up more thoroughly in the teaching of physics, not only in colleges, but also in high schools, and that the units of light might even be treated in connection with the teaching of measurements in arithmetic. We can hardly expect that the relations of light quantities will be as broadly studied as the common measures of length, volume, weight, etc., but they might very reasonably be included in the training of all technical students.

I note Mr. Auel is opposed to States' rights. This principle certainly has made the code problem a much more difficult one in this country than it was in England, where there was but one government to deal with. The difficulty, however, as regards lighting codes is a small matter compared with the corresponding confusion in other classes of state law, as has been pointed out by Mr. Harrison.

The question of Federal *versus* State enactment is certainly too big a problem for the Committee on Lighting Legislation to undertake to secure modification. The committee has wisely accepted the existing methods of law making and has done the best it could under these conditions. That there should be a general uniformity of action in all states is of course important, and in this connection it is very fortunate that the Committee has been

able to establish a leadership which keeps it in touch with the activities in the different states and enables it to exert a strong standardizing influence.

As pointed out in the paper, the variations in the code so far adopted are not fundamental and are largely confined to undetermined factors, where the experimentation, if properly followed up, should lead to progress followed by uniformity of enactment. All the commissions encountered have seemed to be composed of remarkably sincere, able men, seeking the best interests of the people.

It is true that in one or two instances there seemed to be a tendency on the part of state committees to introduce variations as evidences of individual accomplishment. It does not seem likely, however, that such variations will seriously compromise the ultimate status of the codes. In some ways the variation may be of benefit if the leadership can be maintained. At any rate it cannot be entirely avoided.

No report of hardship has come to me in regard to the enforcement of the Pennsylvania Code and I believe that a fair and common sense interpretation of the rules is likely to be made by the Commission.

In regard to the question of cleaning lighting equipment, it is my recollection that a foot note appeared in at least one of the early drafts of the Illuminating Engineering Society's code, pointing out that the values of required intensity were minima; that lighting equipment should be cleaned and that in the design of lighting installations, at least 25 per cent. allowance should be made for depreciation. I believe this note was transferred to the Advisory Section at the suggestion of a State Commissioner. At that time there was a tendency for explanatory notes to accumulate in the code proper and it seemed advisable to eliminate them as far as possible, confining the rules to the conditions to be maintained and treating the methods of securing them in the Advisory Section. The low intensity values have been explained in the paper. These values have been criticised by some as being too high; by others as being too low. They seem to be about right as safety provisions, in view of the present state of the art.

The practicability of the intensity specification was greatly enhanced by the foot-candle meter, which has been mentioned by

several in the discussion. The instrument devised by Dr. Sharp provides a simple, inexpensive means by which reasonably accurate measurements can be made by relatively inexperienced observers. Such observers are liable to make greater errors in reading the more complex, though more accurate higher priced instruments.

The present foot candle meter is being distributed at cost by lamp manufacturers in the belief that a better understanding of intensity will be favorable to the development of the art. The cost of $2.00 for a model illuminometer, as mentioned by Mr. Tillson, is surprisingly low. The volt meter alone as used in the foot candle meter costs several times this amount.

There have been serious discussions as to ways and means of reducing the cost of the foot-candle meter and there does not seem to be much possibility of any considerable reduction in the present type of instrument unless the demand should be such as to warrant making much larger lots. Considering the expense of handling them, the lamp manufacturers actually lose money on each instrument sold. If anyone can put out a suitable instrument at a lower price, I am sure it would be more than welcome. It is understood that other illuminometers are under development by instrument makers, which, in addition to the present type, should result in a wide distribution of suitable instruments.

Referring to Mr. Perrott's comment regarding the flexibility of intensity values, it should be noted that in every instance so far these values have been adopted by the Commissions and not by act of Legislature. The Commissions have the authority to make changes from time to time. Oregon is the only state in which the Legislature has written any of the definite rules.

I think we are all agreed that the codes should be so authorized that the Commissions can make changes in the rules as necessitated by the advance in the art and without recourse to legislation.

The question raised by Mr. Cowles and others, in regard to the emergency circuits, is an important one. If the specification as written in some of the codes is too literally interpreted, there seems to be considerable possibility of inflicting unnecessary and burdensome expense, especially upon small industries. It is, of course, impracticable to write a specification for each individual

set of conditions. Commissioners with whom I have discussed the question seem to think it preferable to specify for the dangerous conditions and allow exceptions where the duplication of service is shown to be unnecessary. Personally I think it would be desirable to recognize such exception in the rule and make provision so that those entitled to exceptions will understand that they can secure them without difficulty. Consideration should be given in each case to the necessity of the emergency lighting, the liability of failure of lighting service, its extent, its relation to other emergencies and the practicable provisions which can be made to avoid undue hazard. It seems reasonable that whereever emergency lighting is necessary it should be separated from the power circuits in such a way that an overload on the power circuit cannot cause entire failure of the lighting.

The need of more definite glare specifications has been emphasized by Mr. Foltz and others. The Committee has been keenly aware of this need. It has been suggested that rules be made for each type of lighting equipment. On account of the variety of reflecting equipment used with the incandescent lamps, this would be quite an undertaking; moreover, it is almost impossible to draft rules of this type so that they will be fair to all illuminants. There would, therefore, be considerable possibility of stirring up competitive recrimination which might seriously interfere with the general acceptance of the rule.

A definite measurement of the glare effect, independent of the particular equipment, seems to offer a more helpful solution. What is now needed is a simple, inexpensive and reasonably accurate instrument for measuring glare. With such a device available, the illuminating engineering features of the codes could readily be carried to definite conclusion.

L. B. MARKS (Communicated): I have read Mr. Stickney's admirable paper and the discussion thereon.

On behalf of the Committee on Lighting Legislation of the Illuminating Engineering Society, I wish to state that Mr. Stickney has set forth clearly the views of the Committee as I understand them, and that the criticisms and suggestions made by those who participated in the discussion will receive the earnest attention of the Committee.

ILLUMINATION DURING THE RECONSTRUCTION PERIOD.*

BY S. E. DOANE

The present reconstruction period will be no different than other reconstruction periods, in so far as the use of illumination is concerned. We have paid a great deal of attention to many new uses of light, but there has been very little new development. Many manufacturers have had to readjust their factories, install new machinery and generally disarrange their lighting circuits and installations; consequently, we have a rather larger opportunity than usual to apply the principles for which the Illuminating Engineering Society has stood.

It is obvious to us that illuminating engineering has never been a journeyman's job. We must concede that if a man should choose a group from among us, and ask each member to specify the total amount of light required on some specific job, indicating the amount necessary from various directions and the most desirable quality of light, there would not be that close agreement in the replies which would characterize those of a group (even the same group, in fact) who might be asked to calculate the speed, size, type, etc., of a motor to perform some particular function. While many engineering text books are full of exact statements as to power usage, very few indeed contain accurate statements of lighting requirements. We can figure the size of wire and calculate those energy expenditures which one must know in order to maintain a certain power service, but we cannot easily calculate the light required for this same operation, its cost, etc.

The problem which the illuminating engineers of this country are facing to-day is indicated by the various demands for light for the industries and the other activities of life. Everyone knows that we can get along with much less light in street lighting than we can in the lighting of homes, theatres and manufacturing places, but very few appreciate the problems involved in supplying a satisfactory system of illumination for all these various locations.

* Abstract of paper presented before the Chicago Section, March [illegible]

We have discussed this in general terms. We have indicated that "general factory lighting" is something which is so uniform in its requirements that we can make a round statement that about so many foot-candles are required. Likewise, the needs of the illuminating engineer have forced other general statements dealing with the amount of light required for bench operations, etc. I think we have appreciated that these statements were not strictly accurate for any specific design. But for one reason or another, we have hesitated about attacking the problem.

We now appreciate the fact that we must favor much more specific statements as to the amount of light required. To make clear what I mean, I have brought with me a few copies of the proposed lighting code for the state of Ohio as drafted by the Sub-committee, on Illumination, of their Industrial Commission, of which I have the honor to be a member. You will notice that beginning with pages 6 and 7 we have classified in the neighborhood of 300 industrial operations for each of which we have mentioned a mandatory minimum which varies from ½ foot-candle to 5 foot-candles. We have also listed a preferable minimum of ½ foot-candle to 8 foot-candles together with a preferable upper limit varying from 3 foot-candles to some maximum in excess of 12.

My connection with this work has taught me that the men on various classes of work have a fairly clear idea of the amount of light which they require. They are not able, however, to express this in foot-candles. It is only with the foot-candle meter that they are able to measure quickly the amount of light in any given location. In preparing for the code hearings in Ohio, the managers of various industries have borrowed these meters and have attempted to obtain a working knowledge of the amount of light advisable for various operations. As a result some manufacturers stated that the code provisions did not require them to give a sufficient amount of light for many operations.

It is my belief that the time is ripe for illuminating engineering to be put on the same practical basis as other branches of engineering. To do this, it is necessary for us to attempt some definite method of procedure. We may not adopt the wisest procedure at first, but any program we do adopt can be so modified as to best fit our needs. Our procedure may be something as follows:

First: We must establish the foot-candle as a definite unit for common use and must make it well known. We are taught many units at school of which we do not all acquire an active working knowledge. While I believe it will be a long time before we will see the foot-candle taught to children in the grammar schools, I do believe that if this were done, it would be put to more practical use than apothecary weights and measures or even the more common units such as the furlong, knot, etc. I also believe that the time has now come when every institution of higher learning should teach the value of the foot-candle and should teach their pupils that light is measurable as absolutely as is length. Granting this need, the practical question arises as to what program of education to establish.

Second: While the obvious sequel to understanding the value of the unit is, of course, to understand its application, it is possible for us to teach the use of the foot-candle without teaching the origin or the nature of the unit. I imagine that trade conventions will ultimately discuss the quantity of light in various locations as in stores or on various operations as in the factories exactly the same way that they discuss other interests. It seems to me that every organization of lighting men will learn, during the coming period, to discuss the amount of light required for various classes of work exactly as will the various trades.

There is another phase of lighting which in this reconstruction period will be better understood. I have said many times that of the three considerations of good lighting—quality of light, direction of light, and quantity of light—I consider the quantity of less importance than the other two. It so happens that the first considerations of these three which is liable to receive popular attention, is the question of light quantity. Because this is so, I would like to call your attention particularly to the other two considerations. The public is accustomed to think of light quality as the name of an indefinite something of which the scientist has knowledge rather than as a practical consideration for practical people. Women have long since appreciated that light modified by colored shades has its use. The men have been slower to appreciate that manufacturing operations and business locations can suffer by light of improper quality. There is no better illustration of this than in the jewelry business where it

has been the custom to use light filtered through colored glass in the cutting or grading of precious stones. In other manufacturing operations we find in our own works that the lamp giving daylight values is much to be preferred for certain classes of operations. I know of no way of measuring these conditions with anything like the facility with which we can measure foot-candles and we are unfortunately not yet in the position to recommend that the public make common acquaintance with the problem of light quality.

The direction of light has to be considered in two phases:

First: The possibility of light in the proper location being glaring, which may or may not be a question of direction of light. It may, in fact, be a location rather than a direction. I have seen many cases of lighting where a light below the line of vision if properly shielded is a preferred way of lighting a certain operation. If, however, we consider the direction of light apart from the location or source as affecting the visualization of an object, we must recognize that there is a proper combination of light and shadows which gives us the maximum value of lighting. This cannot as yet be definitely or accurately specified and hence the question of light quality and light direction must be left to the judgment and experience of the illuminating engineer.

Our experience in the use of the foot-candle meter has taught us that the amount of daylight which is used in offices and factories has been greatly overestimated. Due to the fact that daylight is screened down by curtains to comfortable amounts, 3 to 10 foot-candles on a desk practically covers the usual range. When one finds that an operation in the factory lighted to 25 foot-candles by daylight does not have too much light, it will be found that 25 foot-candles of artificial light is not too much. Our usual experience is that any work which receives 25 foot-candles by day hardly receives more than a fraction of this by night and hence the thought has grown that daylight operations in the factory are preferable. This is not true of all operations. Those operations which naturally take place in the interior of a shop are forced there by the light requirements of neighboring operations and receive a less amount of daylight because of their interior location. When night comes, the artificial light supplied is more nearly to the daytime standard and hence it will be found that

such operations can be more easily performed under the artificial light.

Daylight is one of the most variable lights known, one of the most irresponsible lights and, excepting for its cheapness, it is much less satisfactory than artificial light in modern installations. Since in many factories certain operations have been installed near a window because of their requirements of high intensities of illumination, the same high intensities should be supplied them in artificial lighting in order to bring artificial lighting up to the high standard of excellence which we expect of it. The general recognition of the foot-candle standard and the general use of some satisfactory instrument for measuring will permit us to furnish the lighting needed to maintain our industrial life at the highest efficiency.

To fully appreciate to what an extent our standardization in this country has assisted its development, one should go to Europe and study the conditions there. We believe our standardization has been wise in dealing with fundamentals which, because of their nature, are standardizable. One may take the screw base, for instance, and appreciate that this is one device where standardization is essential and a tremendous help to the industry. In this country, though one may demand a lamp from one company, the socket from another company, and the shade holder from still another, all can be bought with the absolute assurance that they will fit together and, with the lamp, make a workable unit.

If we review an art or a profession we discover certain points of thought agreement or thought accomplishment which mark epochs. We are passing through one of these epochs in our fields at this time. The orderly building of any industry, profession, or art, requires ordered materials so that we may refer to them understandingly. As an illustration of this let us take the incandescent lamp which has been so well standardized that the makers know they can sell what they make because they make only those things which they know the trade will use. The standardization of the lamp and its accessories are a part of a vocabulary of expression. The correlative standardization of sockets, shade holders, and reflectors are all parts of the same language. While we have had a further extensive knowledge of

the vocabulary, which is known only to a few, my belief is that we are to-day approaching a period when knowledge of light quantity is passing into the community life and expression as other engineering units have passed through it in times which are passed. It is the next big effort for which this Society should stand.

In closing I want to leave with you the thought, and my personal assurance, that the problems of the near future will be largely educational. We must teach the public two things; first, an acquaintance with our unit of light, the foot-candle; second, a realization of the thought that different classes of work or different locations require vastly different kinds of light, upon which we are all agreed at this time within limits—wide limits it is true, but nevertheless, limits whch represent a measure of agreement.

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THE SCIENCE OF MARINE CAMOUFLAGE DESIGN *

BY EVERETT L. WARNER,

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While the purpose of the camouflage employed on ships during the war is now generally known, it can hardly be repeated too frequently, since there are still many persons who think that the patterns were intended to make the vessels invisible, or to simulate the appearance of waves or clouds. This is only true of the very earliest experimental types of camouflage, and the results fell so far short of rendering the ships invisible, that these methods were superseded by a system of painting which aimed to create course distortion.

The sole purpose of this method of painting was to guard vessels against torpedo attack. The torpedo has only a speed of about 35 knots, and the submarine commander will rarely be in a position to fire point blank at a ship. He fires at some point that he expects the ship to reach in a given time. Now if his estimate of the direction in which the ship is steering is incorrect it is obvious that the torpedo will pass harmlessly ahead or astern of its target.

The importance which the Germans attached to a correct estimate of the course of a vessel may be shown by quoting from the confidential manual which they issued to the student officers in the submarine school at Kiel. We find in it the following significant paragraph: "The determination of the track angle, or (what amounts to the same thing) of the enemy's course, is the foundation of the whole art of firing submerged."

* Paper presented before a meeting of the New York Section, Illuminating Engineering Society, May 8, 1919, New York, N. Y.

This should make clear our purpose in going after course distortion. Even if the designs had not succeeded in attaining this result the painting would still have been worth while if it had done nothing more than break up the characteristic forms of a vessel and so conceal its identity. Take for example the ex-German ships of our transport force, the average speed and dimensions of which were of course well known to submarine commanders. In recognizing the identity of one of these vessels the enemy would at once acquire a valuable aid in judging the speed. Let us turn again to the confidential manual from which I have already quoted. It points out that at 1,000 meters, even if the course of the ship has been correctly judged, an error of 2 knots in the estimate of her speed will cause the torpedo to pass 63 meters ahead or astern. So you see how important the element of identity may prove, since it gives a very good line on the speed of well known vessels.

The term "dazzle painting," which was used by the British, to describe the ultimate type of camouflage for course distortion, was a very misleading one, and at one time the Navy Department considered the question of finding a new name. A name was desired which would be at once more descriptive, and at the same time differentiate the American development of camouflage from the British. While no name that proved worthy of acceptance was brought forward, a good deal of merriment was caused by the suggestion "Jazz Painting." It was generally agreed that this epitomized the popular impression about ship camouflage.

Now in reality the designs were very far from being haphazard. There is a definite science underlying them, though it was rather imperfectly understood at the time we commenced our work. Lt. Commander, Norman Wilkinson, R. N. V. R., visited this country for a month, and gave us the benefit of the British experience in ship camouflage. I was in close touch with him during that time, and he showed us all of the tricks and devices of pattern that they had found successful in creating course distortion. We adopted many of them and used them in our designs, but it was not then apparent to us or to Lt. Commander Wilkinson, that there was any general law by which all of these devices could be explained.

Our early designs were prepared by the method of trial and error. If the little wooden model to which the pattern was ap-

plied, gave the necessary distortion when viewed through the periscope in our testing theatre, it would be approved, but we were not able at that time to prepare a design logically with the practical certainty of a satisfactory result. Our understanding of the science of camouflage design was a matter of gradual growth, and was partly the result of accident.

It came about largely through the effort to teach the theory of design to the camoufleurs of the U. S. Shipping Board, three of whom came down to Washington every week to become more familiar with the patterns, which it was their duty to apply to vessels. In order to explain some of the more geometrical of our designs I had made a number of wooden blocks of different shapes, which could be arranged in rows in imitation of the painted pattern upon the model ship. Gradually we began to realize that designs which were by no means obviously geometric were susceptible of explanation along the same lines. Practically every successful design was found to have a definite relation to some solid form or group of forms. Either the actual structural form of the vessel was utilized and altered to give distortion, or purely arbitrary forms were used to gain this same result.

There is nothing really mysterious about the fundamental principles. They involve for the most part merely a new application of the principles of solid geometry.

The chief difficulty in understanding dazzle camouflage has been in acquiring the proper point of view. Scientific men are even more prone than others to misconceptions on this subject, because their whole life is spent in studying things as they are.

Bear in mind that the sole purpose of camouflage is to deceive the human eye. We are, therefore, not interested in things as they *are* but as they *appear*. Of course the appearance of an object is governed just as certainly by definite laws as are its weight or actual dimensions, but the appearance is capable of an infinite number of instantaneous changes, simply by an alteration of position or by an alteration of the source of light falling upon it. Measuring these changes by any other agency than the human eye itself becomes, therefore, a matter of the most extraordinary difficulty.

In order to understand more readily the science of illusion, it is necessary to set aside for the moment your customary interpretation of the word fact. Let us take for example a wall paper pattern of regular recurrent design. Is it not true that you are in the habit of thinking of the pattern as uniform and equal throughout—every rose just as red as its fellow, and every repetition of the pattern as measuring exactly the same number of inches?

It is conceded that those are the actual facts, and that such is wall paper *as it is.* However, it is hardly an exaggeration to say that to the human eye no such pattern exists. If a room were papered with a pattern of recurrent design, and if it were possible to take a photograph with a filter which would eliminate everything but the pattern, it would be quite possible to reconstruct the room from such a photograph and a piece of wall paper.

Every change in the direction of the walls—every corner and projection—would all be indicated by an alteration in the apparent size and shape of our units of pattern. When you have once thoroughly grasped this idea, marine camouflage holds no secrets for you.

You will realize that by changing the normal appearance of the pattern on one of the walls of the room—by distorting it, as it were—we could alter your visual impression of the wall. A regular pattern will not have the same appearance upon a curved surface as upon a flat surface, and if, upon the latter, we paint the pattern as it normally appears upon the curved surface we can give the illusion of a curving wall. This is exactly what was done on some of the ships.

Another illustration may serve to make the matter still clearer, when one of the visitors to the Navy Department was at the periscope in our testing theatre I placed upon the turntable a model of our Type 9, Design K. I asked him to indicate the direction in which he thought the vessel was heading. After a moment's puzzled examination he declared firmly, "That's not a vessel at all. That is a group of bath-houses on the beach."

Let us suppose that a scene painter wished to portray a row of bath-houses upon a curving beach, he would certainly have no difficulty in creating that illusion upon the flat surface of a canvas

Fig. 1.—It is easy to read the course of the gray model on the left, and to see that the bow is turned toward the observer. The camouflaged model is steering an exactly parallel course, but that fact would not be determined easily by the observer. Both the bow and stern appear to turn away.

Fig. 2.—The best explanation of this optical illusion may be found by cutting the bow of a model vessel into sections.

Fig. 3.—The bow of the painted model appears to be turned away from the eye because it imitates the appearance of a vessel which has actually been cut into sections and the sections turned away in a curving line.

Fig. 1.—Any seafaring man would at once know that the bow of the gray model was turned toward him, reading the course very accurately from the width of the bridge. The camouflaged model is on a parallel course but the bow appears turned away, as though the ship were about to collide with the gray one or pass astern of it.

Fig. 2.—In this photograph the gray ship has been replaced by a wooden block embodying the essential features of the bow pattern on the painted model. The end of the block nearest the right-hand edge of the picture has been turned away. Therefore if we project its characteristic appearance upon the model the ship will appear to lie in the same direction as the block.

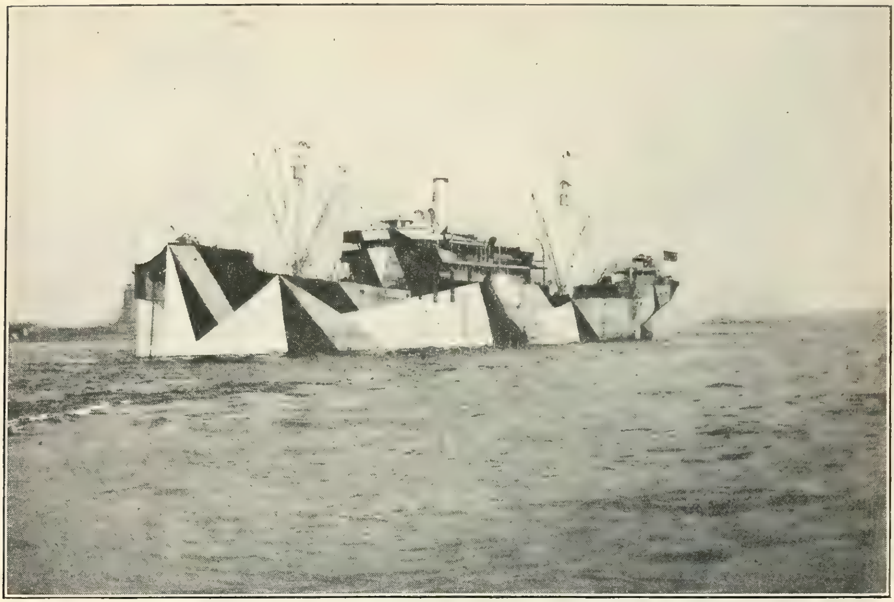
Fig. 3.—The direction of the vessel is shown to be at right angles to that of the block when the two are seen from the low point of view of a submarine periscope (as in Fig. 2.) the painted ship appears to lie parallel to the block, because the camouflage suggests similar solid geometric forms placed in the same position in regard to the eye.

TYPE 1.—Design F.

Fig. 1.—In this photograph the bow of the gray model on the right is turned away from the observer. The camouflaged ship appears to be traveling on a parallel course when seen from the low point of view of the submarine periscope.

Fig. 2.—When viewed from above it is at once apparent that the two models are not on parallel courses but are at right angles to each other. The deceptive effect was secured by imitating the structural appearance of the gray model when the bow was turned away and presenting this effect upon a model which was turned toward the observer.

The loss of deception when the camouflage is viewed from a high point is one of the reasons why dazzle designs were not applied to the battleships. The use of dazzle camouflage was confined to the vessels requiring protection chiefly against submarine attack.



U. S. S. Congaree, Geometric Type of Design.

U. S. S. Montgomery.
Nov. 16, 1918.

at the back of the stage. If the bath houses were cut out of their stage setting and the canvas set up on the beach itself like an advertising sign, the illusion of the curve would still remain.

In much the same manner as the scene painter creates his illusion can we indicate upon the hull of a vessel a series of forms, which will apparently curve toward or away from the observer according to the way in which we draw them, and the ship will appear to be steering in the direction indicated by the pattern.

A few of the many varieties of design, together with an illustration of the principles involved, are shown in the accompanying plates.

PAINTING BATTLESHIPS FOR LOW VISIBILITY.

BY EVERETT L. WARNER,
LT. CONSTRUCTION CORPS, U. S. N. R. F.

I believe we are all in substantial agreement as to the desirability of painting battleships for low visibility, unless some truly effective method of painting to prevent range finding can be devised. Dazzle painting was primarily a defense against torpedo attack, and was only carried out on the battleships experimentally.

Our problem then is narrowed down to a determination of the most suitable shade of paint. I should like to preface what I have to say on this subject by the statement that my present views represent an almost complete reversal of the opinions which I formerly held.

While our present Standard Navy Gray is doubtless susceptible of improvement, particularly in regard to its application to superstructure and masts, I am now of the opinion that for general service it is the best shade of paint that has been brought forward for use on the battleships. At one time I was of the opinion that Navy Gray is much too dark, but opportunities for observing ships of the line operating in fleet formation have been in part responsible for my change of view.

I intend to confine myself to a discussion of the most suitable shade of paint for our battleships, for while I am confident that some of my conclusions are equally applicable to other types of Navy vessels, I am aware that different conditions of operation may make different shades of paint desirable, and my observations of other types have been much more limited.

Data obtained by general observations on the sea and sky, or upon isolated vessels will not prove applicable to the fleet. So different are the conditions that the fleet may almost be said to carry its own sky around with it. A veil of smoke almost invariably hangs over that quarter of the horizon in which a line of battleships is manouvering, and sometimes this pall is so dark that even Standard Gray ships show up light against it. The oil-burning vessels are not supposed to give off this smoke but they usually do give off quite a little, and it has been customary to have

both coal-burners and oil-burning vessels operate together in the same unit. Just why this has been the custom I do not know. There is doubtless some good reason for it, though it would seem at first thought both to complicate the question of fuel supply, and at the same time rob the oil-burners of the advantage accruing from their light smoke.

During a week spent on board the battleship Arizona in April 1918, I saw the U. S. S. New Jersey appear too light against this smoke veil on repeated occasions. For the purpose of visibility observations the New Jersey was to all intents and purposes a light gray ship. In reality she was painted in small patches of red, green and violet, but the color blended into a gray at a very short distance, and though she remained visible up to very great ranges it was always as a gray ship. Even high magnification did not bring back any effect of color, though at medium ranges the hull had a slightly dappled appearance.

It has been proposed to solve the problem by producing a shade of paint which shall have a reflecting power equal to the value of the weather coefficient—the weather coefficient to be determined by summarizing data obtained during a year, let us say, in a particular locality, if special service is being considered, or in many localities if it is a question of general service.

The paint mixed on this basis would unquestionably be very much lighter than the present Navy Gray, but I cannot feel any confidence in an average reached in this way. I see no more reason for painting our ships an average color than for a navy gunner to train his gun squarely between two targets. An average color would neither be satisfactory in sunny weather nor in gray weather. It would achieve the desired result only on those days which were neither one nor the other, and would only prove successful in a locality where such weather was characteristic and typical.

No shade of paint can hope to give low visibility all of the time, and I am firmly persuaded that no shade has sufficient latitude to bridge the great gap which exists between the requirements for sunny and overcast weather. We must choose at which target we will aim. In this connection I should like to quote the opinion of the French experts given in the *73rd Supplement* to the *Bulletin of Submarine Warfare* (No. 278, May

17, 1918). "It is incorrect to claim that an object on the sea painted in such or such a way is any more or less visible. Nothing is positive on this question, and an object * * * if it is rendered less visible for a definite reason in a certain light, will be rendered more visible *for the same reason* in another light." I believe we must resign ourselves to the fact that no matter what paint we choose for our ships it will prove to have a high visibility part of the time. Since in general service our ships must face widely varying conditions, and since even in one locality the paint best suited to reduce visibility at noon may be quite ineffective in the early morning or evening light, the benefit resulting from even the best selection of paint will be very much less than we would like to believe. It can never be comparable to the advantage gained upon land where the background of an object is more or less constant.

Formerly I believed that since it was shown that gray weather prevailed for about 70 per cent. of the time in the war zone the logical course would be to choose the color giving the maximum result on cloudy days, and trust in Providence for the rest of the time. I now believe this conclusion to have been dictated more by statistics than by reason, and nothing is more dangerous than a mass of statistics when not interpreted in the light of reason. It makes people so tremendously sure of things that are not so. The vital question is not what is the most characteristic weather, but *under what weather conditions do the ships most need protection.* This surely points to sunny weather, since it is then that visibility is best and ships can be seen at the greatest ranges.

No matter what their color, in overcast weather ships will be commonly lost to view at a distance of 3 or 4 miles, and possibly even at a distance of less than a mile. Within the field of visibility it will be frequently difficult to distinguish a white ship from a black ship, as both may appear as dark silhouettes against the sky. In such weather the illumination of the vertical surfaces of a vessel is so low that the whitest paint that we can procure generally proves inadequate to match the luminosity of the sky.

If you decide to work for cloudy weather, you are choosing the time when your paint will have the minimum effect in altering the appearance of the vessel, and also the time when nature is

most lavish with her own methods of concealment. If your paint does aid slightly in reducing visibility it will be within a circle with a radius of perhaps 3 miles. If on the other hand you choose sunny weather, your paint will offer some measure of protection within a circle having a radius of 10 to 15 miles, let us say. A computation of the areas of circles will at once show you that the vastly greater area in which you are securing results is worth considering even in a locality where the weather is cloudy 70 per cent. of the time.

I have given the most important reasons why I believe that, if only one shade of paint is to be applied to a vessel, something not very far removed from the present Standard Navy Gray will prove to be the best for general service. No other color has given as good results for bright sunny weather. I am a strong advocate of a modification of the use of battleship gray, by a system to which we gave the name of "Graded Gray" in the experiments which were started in the Navy. This was frequently confused with the so-called "German System" which was supposed to consist in the use of dark paint at the water line, lightening it through successive shades as the paint was carried up on the vessel. The graded gray system was based on a wholly different and sounder principle. Standard Gray was applied to the hull because it presented a large unbroken surface to reflect the light, and the superstructure which was badly broken up with all kinds of gear, was painted a lighter shade simply because the reflecting surfaces were smaller and the whole mass penetrated with numerous shadows. The intricate network of rods in the cage masts was painted a pure white. We did not paint the fighting tops or the fire-control platforms white because the theory was not to grade upwards from dark to light but to determine the shade to be used in accordance with the size and character of the reflecting surface. The aim was to so equalize the effect that at a short distance the vessel would present a uniformly gray appearance.

The most important feature of this system was the lightening of the cage masts. In Standard Gray they invariably appear too dark against the sky in all lights and all weathers, and it is upon them that the range-finder operator takes his readings when the vessel is hull down below the horizon. While I am confident

that this manner of painting the masts will reduce by a number of thousand yards the distances at which effective ranges can be read, interest in this system has lagged since the cessation of hostilities, and the Navy Department does not now seem inclined to carry the experiments through.

U. S. S. Ohio, Sept. 17, 1918. Painted in Graded Gray

U. S. S. Ohio, Sept. 18, 1918. Painted with Standard Navy Gray

CAMOUFLAGE.*

BY LT. HAROLD VAN BUSKIRK

In summarizing the growth of protective painting, now commonly called "camouflage" during the European War, I will endeavor to confine myself to an outline of the progress made in the United States before and after the Navy Department took over and organized its camouflage section.

Prior to the war there was practically no art, much less science of painting vessels for protective purposes except monotone color variations used on vessels of the fleet.

Many claims have been made by individuals as being the pioneer camoufleur of this country. According to all records obtainable this honor goes to Geo. de Forest Brush and Abbott Thayer, who first took up the matter of protective coloration with the Navy Department in 1899. Unfortunately this did not lead to serious trials being made at that time.

Probably the first direct stimulus to camouflage painting was given by the instructions issued in May, 1917, to American vessels, stating that all white or light colored superstructure should be painted gray or dull stone color.

Definite action was not started until Oct. 1, 1917, at which time the Bureau of War Risk Insurance of the Treasury Department adopted the five systems proposed respectively by Messrs. Brush, Herzog, Mackay, Toch and Warner and required their use under a penalty of ½ per cent. increase in war risk premium.

These five accepted systems are broadly classified under two heads, one which had its basic idea of reducing visibility and the other with the idea of confusing the observer as to type course and speed of a vessel. The Brush, Herzog and Mackay systems are clearly classified under the former. The Warner system was originally the only one to attempt the latter method, but the Toch system, although its foundation was low visibility, later developed some slight indication of attempting course distortion.

During the early part of the war the British went through much the same process of development, adopting finally in the latter part of 1917 the so-called "Dazzle" system.

* Paper presented before a meeting of the New York Section, Illuminating Engineering Society, May [illegible], New York, N. Y.

It was at this stage that the Navy Department in Feb., 1918, started the organization of its Camouflage Section. Again arose the question of which policy to follow—"Low Visibility" or "Dazzle." The adoption of the "Dazzle" was made and why?

To successfully surmount the infinite number of difficulties found when trying to reach invisibility at sea, providing such a thing is possible, it is first necessary to have precise information concerning the quality, quantity and distribution of the light in the zones under consideration.

No data of this character had been collected so that all conclusions drawn in respect to low visibility methods were theoretical rather than positive.

On the other hand the amount of course distortion given a vessel by means of a dazzle design is something that could be estimated and checked in each individual case by the ship masters.

And so as the British "Dazzle" had been in use for several months and the reports received from naval officers were highly favorable, while the reports received concerning low visibility systems were still conflicting and uncertain. The Bureau of Construction and Repair requested and received the authorization from the Secretary of the Navy to adopt a system similar to the British, but to continue experiments and tests with other methods.

The work of painting vessels divided itself naturally into two parts: First, that of furnishing designs and second, the supervision of their application to vessels. It was deemed impracticable at the time to attempt to carry on this entire work under the Navy due to the great number of officers it would require to be appointed at one time. To overcome this, the creating, testing and furnishing designs, which was considered the military feature of the work was turned over to the Navy Departments' organization, while the supervision of the practical application was given the civilian organization of the Shipping Board.

To further explain this co-organization I will quote three paragraphs from a letter of Secretary Daniels to the Emergency Fleet Corporation of the Shipping Board, dated March 25, 1918 on this subject:

(*a*) "The Navy Department (Bureau of Construction and Repair) will have charge of all camouflage designs, which will

include the investigation of suggestions as to schemes of camouflage and the issuance of definite instructions as to the type of camouflage to be adopted.

(*b*) The Emergency Fleet Corporation (The Shipping Board) will have charge of the practical application of camouflage to vessels.

(*c*) The design furnished by the Navy Department (Bureau of Construction and Repair) is not to be departed from except where it may be necessary (owing to discrepancy between the dimensions shown on the plan and those of the actual ship) to expand or contract a portion of it. *The color is not to be departed from.* A book containing standard colors will be supplied; these colors as per numbers are to be followed instead of the color of the plan which may not be exact, as the plans are for purposes of measurement and general information as to color. No actual redesigning is to be done nor are colors not in the plan to be introduced. The designs will be carefully thought out and tested with the aid of a periscope before issuing and any radical alteration is liable to prevent obtaining the desired results."

I had the honor of being placed in general charge of the Navy's organization and was fortunate indeed in being given the assistance of Lt. Warner and Lt. Jones, who were placed in charge of the sub-section of design and the sub-section of research respectively.

The design sub-section originated and developed all designs on models, prepared type plans and transferred all approved designs to the type plans ready to issue.

The research sub-section had charge of all original investigations in connection with new systems of camouflage that were proposed, as well as a special investigation to determine the exact physcological value of the Dazzle system. This sub-section also had charge of designing and building very specialized types of portable photometers and colorimeters for collecting the desired quantitative data on the quality and distribution of light under various conditions at sea.

To briefly summarize the method of procedure in the production of a camouflage design the following example is given:

On April 21, I received a request for a design for the U. S. S.

George Washington, due to arrive at New York, April 27, and due to sail May 2. The blue-prints of this vessel were obtained at once and outboard profiles and fore and aft elevations of the main superstructure were drawn at 1/16 inch to the foot. At the same time construction was started on a wooden model of the vessel at a scale of 1/32 inch to the foot. As soon as the drawing was completed it was sent to the geological survey for copies. The model on completion was turned over to the design room. Here a design for this particular vessel was considered, tried and finally developed, with the aid of a submarine periscope looking over a false sea towards changeable sky backgrounds, which were operated from the periscope. On the sea, at a distance representing 2,700 yards or 1½ miles was a turn table which also operated from the periscope. In this way the model placed on the turn table could be observed from the periscope at various angles with varying sky backgrounds and lighting conditions. In order to obtain a veiling glare such as exists at sea due to fog, mist, smoke, etc., a movable semi-transparent mirror was mounted between the observer and the model to reflect scattered light into the eye of the observer in a way entirely analogous to condition existing in nature. Generally the design had been approved by the time the printed forms had been returned from the geological survey. The model bearing the approved design was then turned over to the draughting room where it was transferred to the outboard prints. This entire process averaged four to five days so that in this case on the morning of April 26 the design of the George Washington was mailed to the Navy Yard, New York, by special delivery and there awaited her arrival.

In the case of all shipping board vessels this final color chart was returned to the survey and lithographed in quantity, as copies were sent to all of their district camoufleurs to cover vessels of that particular type.

The preliminary arrangements of the section provided for only the painting of Navy and shipping board's vessels. Later, on June 3, further arrangements were made to paint all army controlled vessels and then in September an agreement reached with the Railroad Administration resulted in all tonnage under their operation, being painted as prescribed by the Navy Department.

As this meant that all American vessels sailing the high seas

were to be camouflage painted, the work necessarily grew to such proportions that it was necessary to establish priority lists. For these the following precedence was given:

(*a*) Troop transports.

(*b*) Destroyers, cargo and supply vessels.

(*c*) Cruisers and gun boats.

It might be well to add here that no camouflage designs were prepared for battleships, except for experimental work, due to the fact that the operation of these vessels in fleet formation, and the fact that they were observed from high vantage points, tended to nullify the effect of the design in deceiving an observer as to course and speed. Furthermore, in this class of vessel, deception as to range is greater to be desired than that of course.

In closing it is interesting to note the following statistics obtained from the present available information.

Approximately 1,256 vessels were camouflage painted from March 1, 1918 to November 11, 1918, a period of 8 months. In that time 96 American ships of 2,500 tons and over were sunk, only 18 of which were camouflaged, of these 18—11 were sunk by torpedo, 4 by collision and the remainder by mines. This means that less than 1 per cent. of the vessels painted were sunk by torpedo.

The approved designs issued totaled 495 and of this number, 193 were made for Navy vessels and 302 for shipping board vessels. Thirteen of the 302 designs prepared for the shipping board were made by their own camoufleurs while undergoing a short period of intensive training in the Camouflage Section.

It is of further interest that no vessel was lost, painted with one of the 193 designs made for Navy vessels. All of the 11 sunk were painted with designs made for and issued to the shipping board.

As previously noted all troop transports were given precedence and were painted as quickly as possible. None were sunk however, once camouflage painted.

The President Lincoln is a case worthy of note as here the design was issued previous to her sailing but due to the other stress of work at the yard, she was not painted before her last and fatal journey.

DISCUSSION.

Maximilian Toch (In reply to Lt. Warner and Lt. Van Buskirk): It was my good fortune the first week of the war to be called down to the Navy Department to the Bureau of Yards and Docks, which department really took up the first camouflage of the United States, and I had the mission thrust upon me of going along the coast of the United States and designing and executing the camouflage of the yards and docks and a number of fortifications. That was long before the question was taken up as to the kind of system that was to be used on the boats.

There was a very good story told about me at the Chemists' Club with regard to my early work, and I don't think it is a disgrace for any man to tell a story on himself. When I was called to Washington during the first week of the war, it was because in 1915 I had camouflaged two forts at Panama. In those days the word "camouflage" was totally unknown. The words used were "military concealment," and on the question of the visibility of color and juxta-position of color, these two fortresses which contained disappearing guns were given to me to distort and to lower their visibility. When the work was given to me to proceed along the coast and see what could be done with the yards and docks and fortifications, I was given a letter and instructed that under no circumstances was anybody to know what I was doing or where I was going. It was really a secret mission and was practically as if it were under the Intelligence Bureau of the Navy.

Shortly after the Armistice, sitting around at the Chemists' Club one night, I told of the work that I had done, and I said that from 2 to 8 weeks at a time I left my wife and family and I always said I went to Washington, but from there, of course, I went as far around as the Gulf of Mexico, because I had work to do on the Gulf of Mexico and Key West, and I sent a man to Cuba and New Orleans. When I came back my family never asked a word and I went away again. And some one of the men said: "Any man who could leave his wife and go away for 2 weeks to 2 months at a time and come back and not even have her ask where he went to, and get away with it, deserves to be the first camoufleur in the service of the Government."

One of the most important pieces of work done, and that has been very largely published in the papers here of late, was the work that was done with regard to the secret fortifications around the City of New York. I think it may interest you to know that Ambrose Channel in New York was guarded by mortars each having a radius of 20,000 yards, not one of these mortars visible to a single soul excepting to the engineers, and all of these mortar batteries were placed in what looked like tennis courts in private residences along the Jersey and Long Island coasts. It was those fortifications, those mortars in the private gardens that I was given to camouflage, and there was very little paint that had to be used on them, if any. Shrubbery was the best, I found. The great difficulty was, of course, in destroying the shadows. The sun would rise and cast a long shadow. Of course, nobody could see these from the land; you couldn't even tell they existed unless you went right up to them, but what we tried to do was to cover them up entirely from airplane view so that no airplane that flew over them could even photograph them, and we did that very successfully by means of trailing various kinds of vines and growths and flowers and shrubs over the parapet walls and over the guns, so that the whole matter was so completely hidden from a distance of 800 or 1,000 feet up in the sky that even a photograph could not determine what was beneath.

The first workers on the ship camouflage were Messrs. Mackay, Jerome Brush, Louis Herzog, Lt. Warner and myself, and of course in those days we hadn't the guidance of the brilliant scientific research of Messrs. VanBuskirk, Warner and Jones. I was in at the very beginning but I was the one man—and I trust you won't think this is egotistic—who fought against low visibility from the very beginning, notwithstanding the great knowledge of Mr. Jones to the contrary. I felt from my experience in artistic photography, and I showed a number of photographs to substantiate it, taking flocks of white sea gulls against the light they would always show up dark, and taking them with the light they would show white, that therefore I concluded that no matter how thoroughly a boat was camouflaged, against the rising or setting sun it was absolutely impossible to make it invisible. I was very glad to see Lt. Warner show photographs which substantiated that. The amount of work which was done was of course very remarkable.

I had both army and navy work to do, and one of the most interesting things that happened to me throughout the entire course of my work was going to sea in a submarine and watching the effect of the camouflage ships. The whole work was so well done that, as you heard Lt. VanBuskirk say, there was less than 1 per cent. of the boats hit by torpedoes, which were camouflaged.

DESCRIPTION OF THEATRE AT ROCHESTER, DESIGNED AND BUILT UNDER THE DIRECTION OF LT. L. A. JONES.

In order that the efficiency of any scheme of deception coloration be carried out it was necessary to imitate as completely as possible all of the conditions under which such a system is supposed to operate. These conditions include such factors as the quality, quantity and distribution of the light on the protectively colored craft, the conditions of the observations by the enemy, etc. Since the most urgent problem was that of protection of surface craft from attack by submarines, that phase of the subject was given the most attention and the apparatus designed and built was for the study of that particular problem.

In order to reproduce lighting conditions as closely as possible a shallow tank 14 feet in diameter and 12 inches deep was constructed upon which when filled with water, the model to be examined was floated as in photo No. 1. Over this tank a dome of diffusing material was erected which when lighted from without gave a lighting condition upon the model similar in quality and distribution to that resulting from the sky illumination, as in photo No. 2. Inside of this dome a single high intensity electric lamp was mounted on a movable arm so arranged that direct light similar to that from the sun could be thrown on the model, from

Photo No. 1

Showing model floated in shallow tank ready to be examined from periscope, which moves on tracks seen in foreground

The cam apparatus for turning vessel is seen on the left

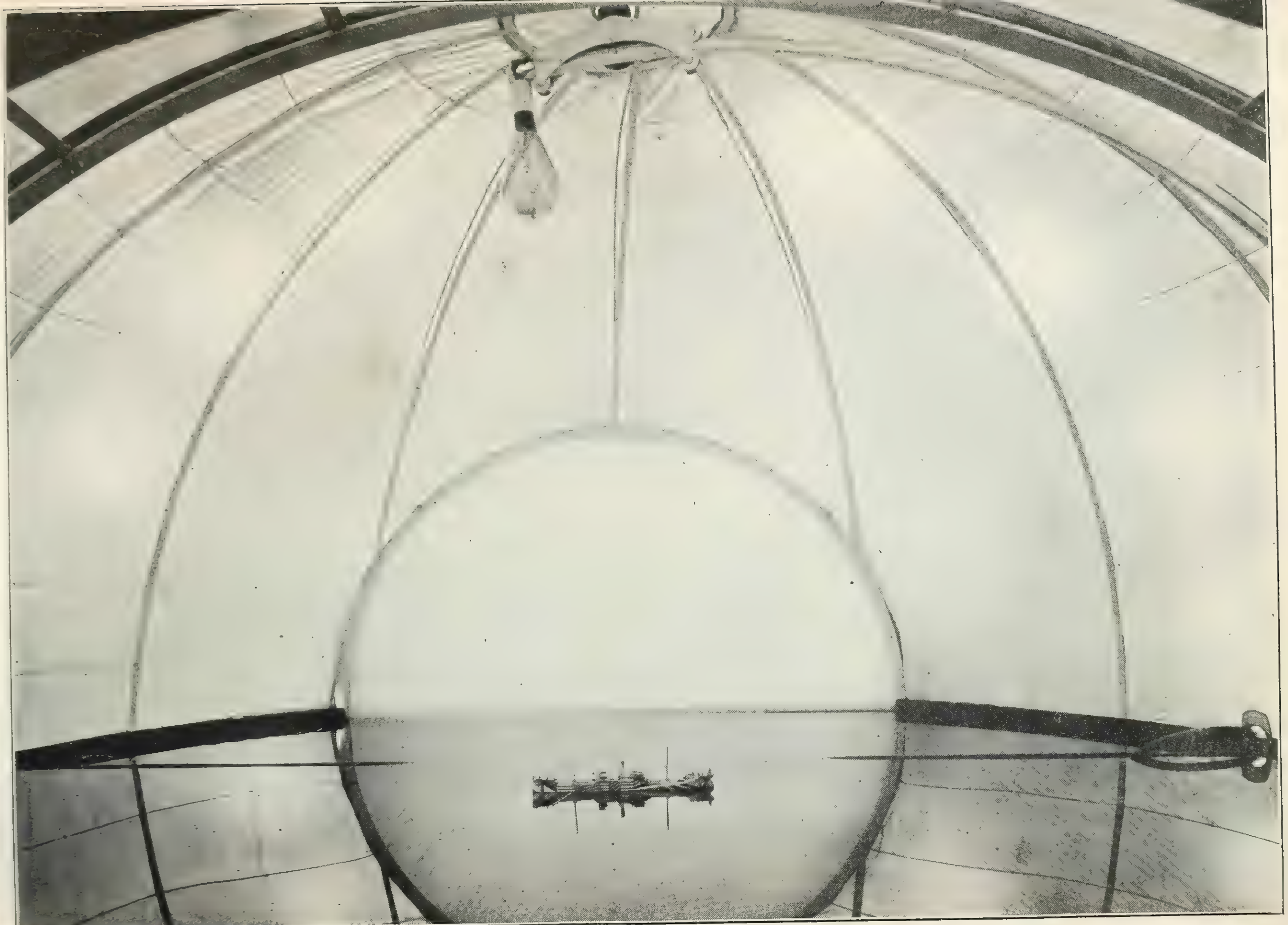


Photo No. 2.

Showing diffusing material over tank to produce equal distribution of light. Above is seen the artificial sun of a high intensity bulb on a movable arm so designed as to make any azimuth or altitude of the sun obtainable.

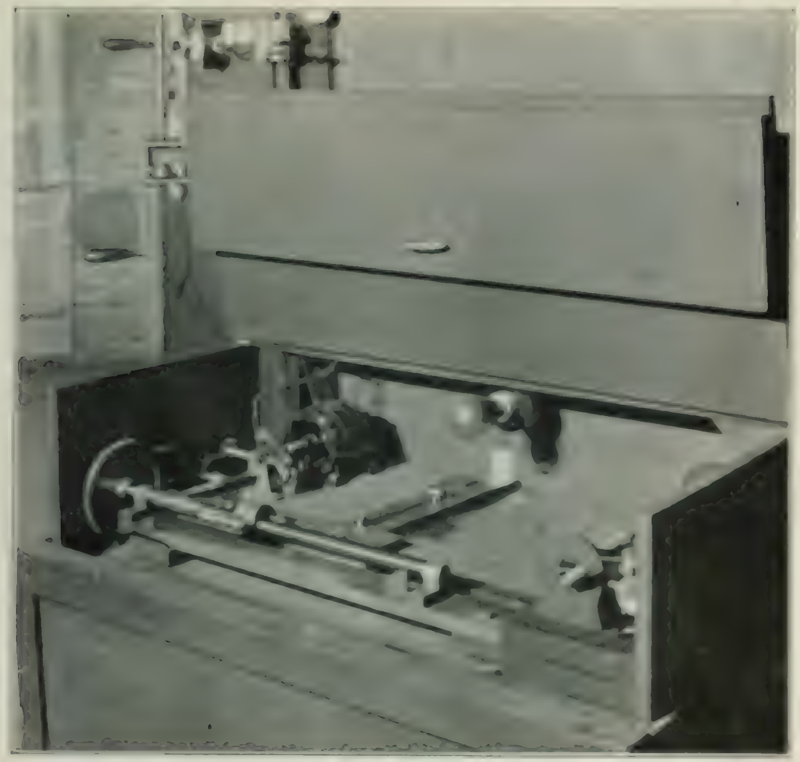


Photo No. __.
Showing cam and motor for change orientation of vessel at a given speed

Photo No. 5.
Showing the controlling end of periscope and reflecting mirror, and also the [illegible] the speed of the mirror [illegible] as seen from the [illegible] the [illegible]

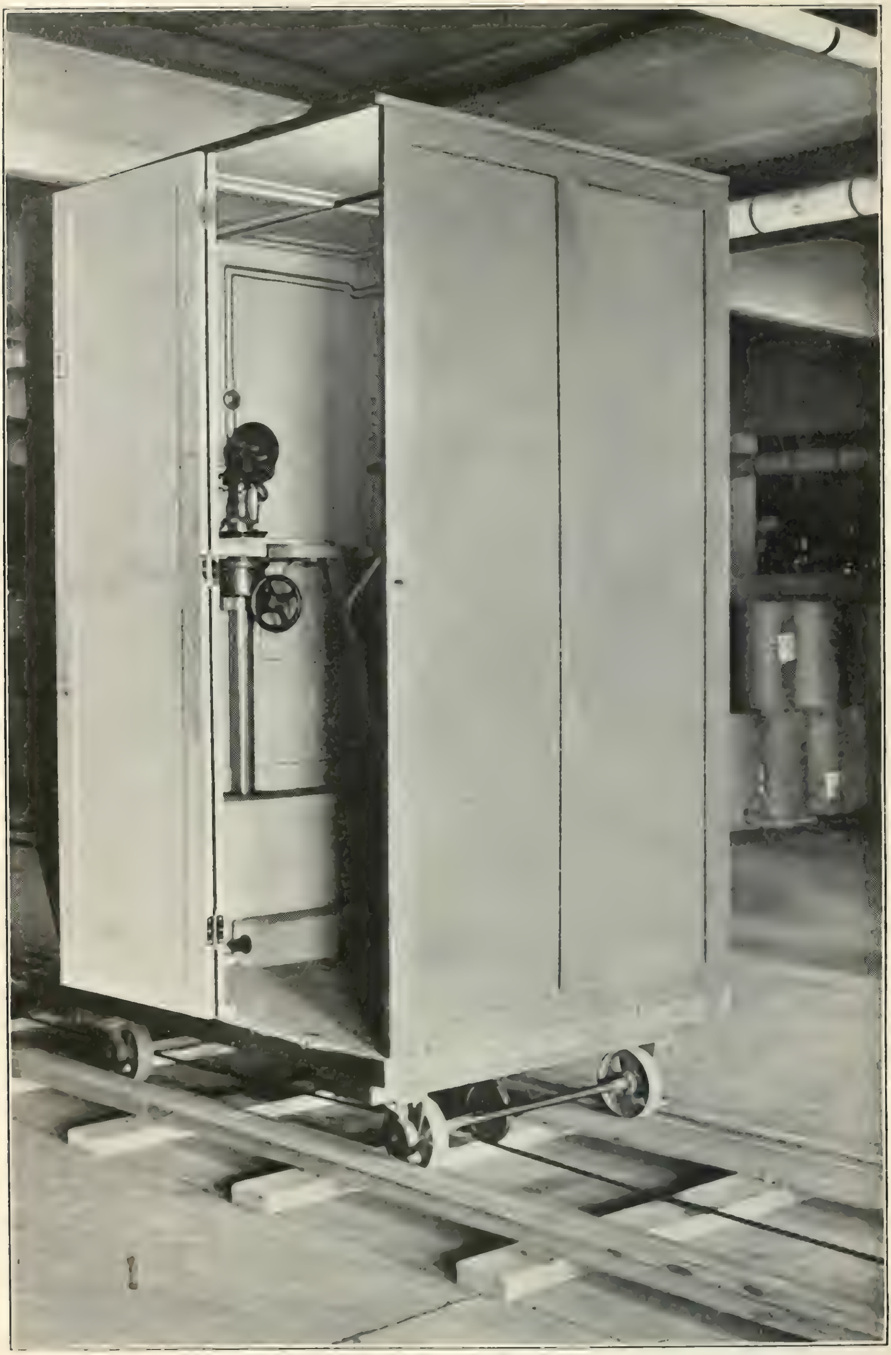


PHOTO No. 4

Showing submarine enclosure, periscope, tracks and cable on which it operates

PHOTO No. 6.
An idea of the number and variety of models.

any desired direction, thus producing the shadow effects of sunlight, as in photo No. 2. Behind the model was mounted a painted curtain carried on two rolls so arranged that a background of any desired brightness and quality could be brought into position for examination of the various models under specified conditions.

The models were mounted on a floating support which could be brought into any orientation with respect to the observer, by the use of a cam and motor set in motion at a known speed as seen in photo No. 3. They were then examined through a special periscope mounted in a small truck, as in photo No. 4, enclosed so that the observer could be subjected to the same conditions of lighting as exist in the interior of a submarine thus keeping his eyes in the same condition of adoption as those of a submarine observer. The truck was mounted on a track 130 feet long at a scale of 1 to 250 in both yards and knots, which approached the tank on which the model was placed for examination. This truck was driven either towards or away from the model at any desired velocity by means of a motor and a speed control cam. The periscope was mounted so that the model was viewed by reflection from a mirror as shown in photo No. 5, movable in such a way that the model appeared to be traveling across the course of the truck at any desired angle. The speed of this mirror was regulated also by the motor which drove the truck. This made it possible to approach a vessel going at a known speed on a known course or zigzag in a submarine traveling at a known speed, and

FIG. 1

from it make observations as shown in Fig. 1 at certain intervals to determine the effect of any camouflage pattern that might be selected.

THE PRINCIPLES OF CAMOUFLAGE.*

BY M. LUCKIESH.**

TERRESTIAL CAMOUFLAGE.

Camouflage is an art which is the natural outgrowth of our instinct for concealment and deception when pitting our wits against those of a crafty prey or enemy. It is an art older than the human race for its beginnings may be traced back to the obscurity of the early ages of the evolution of animal life. The name was coined by the French to apply to a definite art which developed during the great war to a high state, as many other arts developed by drawing deeply upon the resources of scientific knowledge. With the introduction of this specific word to cover a vast field of activity in scientifically concealing and deceiving, many are led to believe that this is a new art, but such is not the case. However, like many other arts, such as that of flying, the exigencies of modern warfare have provided an impetus which has resulted in a highly developed art.

Scientists have recognized for many years, and perhaps more or less vaguely for centuries, that Nature exhibits wonderful examples of concealment and deception. The survival of the fittest as Darwin expressed his doctrine, included those individuals of a species who were best fitted by their markings and perhaps by peculiar habits to survive in the environment in which they lived. Naturally, markings, habits, and environment became more and more adapted to each other until the species became in equilibrium with Nature sufficiently to insure its perpetuity. If we look about us upon animal life we see on every hand examples of concealing coloration and attitudes designed to deceive the prey or enemy. The rabbit is mottled because Nature's infinite variety of highlights, shadows, and hues demand variety in the markings of an animal if the latter is to be securely hidden. Solid color does not exist in Nature's landscapes in large areas. The rabbit is lighter underneath to compensate for the lower intensity of illumination received on these portions. As winter ap-

* A Resumé of a lecture presented before the Chicago Section of I. E. S., Dec. 19, 1918, and before a joint meeting of Boston Sections of I. E. S. and A. I. E. E., Jan. 7, 1919. The lecture was accompanied by 120 lantern slides.

** Chairman, Committee on Camouflage, National Research Council.

proaches, animals in rigorous climates need warmer coats, and the hairs grow longer. In many cases the color of the hairs change to gray or white providing a better coating for the winter environment.

Animals are known to mimic inanimate objects for the sake of safety. For example, the bittern will stand rigid with its bill pointed skyward for many minutes if it suspects an enemy. Non-poisonous snakes resemble poisonous ones in general characteristics and get along in the world on the reputation of their harmful relatives. The drone-bee has no sting, but to the casual observer it is a bee and bees generally sting. Some animals have very contrasting patterns which are conspicuous in shape, yet these very features disguise the fact that they are animals. Close observation of fishes in their natural environment provides striking examples of concealing coloration. Vast works have been written on this subject by scientists, so it will only be touched upon here.[1]

There are many examples of "mobile" camouflage to be found in Nature. Seasonal changes have been cited in a foregoing paragraph. The chameleon changes its color from moment to moment. The flounder changes its color and *pattern* to suit its environment. It will even strive to imitate a black and white checkerboard.

In looking at a bird, animal, insect, or other living thing it is necessary to place it in its natural environment at least in the imagination, before analyzing its coloration. For example, a male mallard duck hanging in the market is a very gaudy object but place it in the pond among the weeds, the green leaves, the high-lights, and the shadows and it is surprisingly inconspicuous. The zebra in the zoo appears to be marked for the purpose of heralding its presence anywhere in the range of vision but in its reedy, bushy, grassy environment it is sufficiently inconspicuous for the species to survive in Nature's continuous warfare.

Thus studies of Nature reveal the importance of general hue, the necessity for broken color or pattern, the fact that black spots simulate shadows or voids, the compensation for lower illumination by countershading, and many other facts. The artist has aided in the development of camouflage, but the definite and working basis of all branches of camouflage are the laws and facts of light, color, and vision as the scientist knows them.

Just as lower animal life has unconsciously survived or evolved by being fitted to do so, mankind has consciously, or at least instinctively, applied camouflage of various kinds to fool his prey or his enemy. Many of us in hunting ducks have concealed the bow of our sneak-boat with mud and weeds, or in the season of floating ice, with a white cloth. In our quest of water fowl we use decoys and grass suits. The Esquimau stalks his game behind a piece of ice. In fact, on every hand we find evidences of this natural instinct. The Indian painted his face and body in a variety of colors and patterns. Did he do this merely to be hideous? It seems very possible that the same instinct which made him the supreme master of woodcraft caused him to reap some of the advantages of concealment due to the painting of his face and body.

In past wars there is plenty of evidence that concealment and deception were practiced to the full extent comparable with the advantages or necessity. In the great war the advent of the airplane placed the third dimension in reconnaissance and called for the application of science in the greatly extended necessity for concealment and deception. With the advent of the airplane, aerial photography became a more important factor than visual observation in much of the reconnaissance. This necessitated that camouflage in order to be successful had to meet the requirements of the photographic eye as well as that of the human eye. In other words, the spectral characteristics of the colors used had to be similar to those of Nature's colors. For example, chlorophyl, the green coloring matter of vegetation, is a peculiar green as compared with green pigments. When examined with a spectroscope it is seen to reflect a band of deep red light not reflected by ordinary pigments. In considering this aspect it is well to bear in mind that the eye is a synthetic apparatus; that it does not analyze color in a spectral sense. An artist who views color subjectively and is rarely familiar with the spectral basis may match a green leaf perfectly with a mixture of pigments. A photographic plate, a visual filter, or a spectroscope will reveal a difference which the unaided eye does not.

Some time before the great war began, it occurred to the writer that colored filters could be utilized in aiding vision by increasing the contrast of the object to be viewed against its surroundings.

Studies were made of various filters, made with the object of the experiment in mind, in viewing the uniforms of various armies. Further developments were made by applying the same principles to colored lights and painted pictures. Many of these have been described elsewhere.* With the development of the science of camouflage, filters came into use for the detection of camouflage. As a result of the demand for avoiding detection by photographic plates and by various colored filters, some paints provided for the camoufleur were developed according to the spectral requirements. Many other applications of science were developed so that camouflage can now be called an art based upon sound scientific principles.

Natural lighting is so variable that it is often impossible to provide camouflage which will remain satisfactory from day to day; therefore, a broad knowledge of Nature's lighting is necessary in order to provide the best compromise. There are two sources of light in the daytime, namely, the sun and the sky. The relative amounts of light contributed by these two sources is continually changing. The sky on cloudless days contributes from one-tenth to one-third of the total light received by a horizontal surface at noon. Light from the sky and light reflected from the surroundings illuminate the shadows. These shadows are different in color than highlights although these finer distinctions may be ignored in most camouflage because color becomes less conspicuous as the distance of observation increases. In general, the distribution of brightness or light and shade is the most important aspect to be considered.

The camoufleur worries over shadows more than any other aspect generally. On overcast days camouflage is generally much more successful than on sunny days. Obviously, counter shading is resorted to in order to eliminate shadows and where this is unsuccessful confusion is resorted to by making more shadows. The shape and orientation of a building is very important to those charged with the problem of rendering it inconspicuous to the enemy, but little attention has been paid to these aspects. For example, a hangar painted a very satisfactory dull green will be distinguishable by its shape as indicated by its shadow and shaded sides. In this zone a hangar, for example, would be more readily concealed if its length lay north and south. Its sides could be

brought with a gradual curve to the ground and its rear, which is during most of the day in shadow, could be effectively treated to conceal the shadow. A little thought will convince the reader of the importance of shape and orientation.

Broken color or pattern is another fundamental of camouflage which, of course, must be adapted to its environment. For our trucks, cannon, and many other implements of war, dark green, yellow, dark blue, light gray, and other colors have been used in a jumble of large patterns. A final refinement is that of the blending of these colors at a distance, where the eye no longer resolves the individual patches, to a color which simulates the general hue of the surroundings. For example, red and green patches at a distance blend to yellow; yellow and blue patches blend to a neutral gray if suitably balanced, but if not, to a yellow-gray or a blue-gray; red, green, and blue if properly balanced will blend to a gray; black, white and green patches will blend to a green shade, and so on. These facts are simple to those who are familiar with the science of light and color, but the artist, whose knowledge is based upon the mixture of pigments sometimes errs in considering this aspect of color-blending by distance. For example, it is not uncommon for him to state that at a distance yellow and blue patches blend to make green, but the addition of lights or of juxtaposed colors is quite different in result from the addition of pigments by intimately mixing them.

In constructing such a pattern of various colors it is also desirable to have the final mean brightness approximate that of the general surroundings. This problem can be solved by means of the photometer and a formula provided, which states, for example, that a certain percentage of the total area be painted in gray, another percentage in green, and so on. The photometer has played an important role in establishing the scientific basis of camouflage. The size of the pattern must be governed by the distance at which it is to be viewed, for obviously if too small the effect is that of solid color, and if too large it will render the object conspicuous which is a disadvantage ranking next to recognizable.

Where the artist is concerned with a background which does not include the sky, that is, where he deals only with *illuminated*

objects on the earth his trained eye is valuable provided the colors used meet the demands made by photographic plates and visual color-filters. In other words, the sky as a background gives trouble to all who are unfamiliar with scientific measurements. The brightnesses of sky and clouds are outside the scale of brightnesses ordinarily encountered in a landscape. Many interesting instances of the artist's mistakes in dealing with these backgrounds could be presented, however, the artist's trained eye has been a great aid in constructing patterns and various other types of camouflage. One of the most conspicuous aspects of the earth's surface is its texture. From great heights it appears flat, that is, rolling land is ironed out and the general contour of the ground is flattened. However, the element of texture always remains. This is the chief reason for the extensive use of netting on which dyed raffia, foliage, pieces of colored cloth, etc., are tied. Such network has concealed many guns, headquarters, ammunition dumps, communication trenches, roadways, etc. When this has been well done the concealment is perfect.

One of the greatest annoyances to the camoufleur is the lack of dullness or "flatness" of the paints, fabrics, and some of the other media used. When viewed at some angles the glint of highlights due to specular reflection renders the work very conspicuous. For this reason natural foliage or such material as dyed raffia has been very successful.

Systems of network and vertical screens have been extensively employed on roadways near the front, not for the purpose of concealing from the enemy the fact that the roadways exist, but to make it necessary to shell the entire roadway continually if it is hoped to prevent its use.

Although the camoufleur is provided with a vast amount of material for his work many of his requirements are met by the material at hand. Obviously, the most convenient method of providing concealment for a given environment is to use the materials of the environment. Hence, rubbish from ruined buildings or villages supply camouflage for guns, huts, etc., in that environment. In woods the material to simulate the woods is at hand. Many of these aspects are so obvious to the reader that space will not be given to their consideration.

The color of the soil is important for if it is conspicuous the camoufleur must provide screens or natural turf.

In this great game of hocus-pocus many deceptions are resorted to. Replicas of large guns and trenches are made; dummy soldiers are used to foil the sniper and to make him reveal his location, and papier mache horses, trees, and other objects conceal snipers and observers and afford listening posts. Gunners have been dressed in summer in green flowing robes. In winter white robes have been utilized. How far away from modern warfare are all the usual glitter and glamour of military impedimenta in the past parades of peace time! The armies now dig in for concealment. The artillery is no longer invisible behind yonder hill, for the eyes of the aerial observer or of the camera reveal its position unless camouflaged for the third dimension.

In the foregoing only the highlights of a vast art have been viewed but the art is still vaster, for it extends into other fields. Sound must sometimes be camouflaged and this can only be done by using the same medium—sound. In these days of scientific warfare it is to be expected that the positions of enemy guns would be detected by other means than employed in the past. A notable method is the use of velocity of sound. Records are made at various stations of the firing of a gun and the explosion of the shell. By trigonometric laws the position of the gun is ascertained. It is said that the Germans fired a number of guns simultaneously with the "75-mile" gun in order to camouflage its location. The airplane and submarine would gladly employ sound camouflage in order to foil the sound detector if practicable solutions were proposed.

The foregoing is a brief statement of some of the fundamental principles of land camouflage. Let us now briefly consider the eyes of the enemy. Of course, much concealment and deception is devised to foil the observer who is on the ground and fairly close. The procedure is obvious to the average imagination; however, the reader may not be acquainted with the aerial eyes from which concealment is very important. As one ascends in an airplane to view a landscape he is impressed with the inadequacy of the eyes to observe the vast number of details and of the mind to retain them. Field glasses can not be used as satisfactorily in an airplane as on solid ground owing to vibration and

other movements. The difference is not as great in the huge flying boats as it is in the ordinary airplane. The camera can record many details with higher accuracy than the eye. At an altitude of 1 mile the lens can be used at full aperture and thus very short exposures are possible. This tends to avoid the difficulty due to vibration. When the plates are developed for detail and enlargements are made many minute details are distinguishable. Furthermore, owing to the fact that the spectral sensibilities of photographic emulsions differ from that of the eye, contrasts are brought out which the eye would not see. This applies also to camouflage which is devised merely to suit the eye. Individual footprints have been distinguished on prints made from negatives exposed at an altitude of 6,000 feet. By means of photography, daily records can be made if desired and these can be compared. A slight change is readily noted by such comparison by skilled interpreters of aerial photographs. The disappearance of a tree from a clump of trees may arouse suspicion. Sometimes a wilted tree has been noted on a photograph which naturally attracts attention to this position. It has been said that the belligerents resorted to transplanting trees a short distance at a time from day to day in order to provide clearance for newly placed guns. By paths converging toward a certain point, it may be concluded from the photographs that an ammunition dump or headquarters is located there even though the position itself was well camouflaged. Continuous photographic records may reveal disturbances of turf and lead to a more careful inspection of the region for sapping operations, etc. By these few details it is obvious that the airplane is responsible for much of the development of camouflage on land owing to the necessity which it created for a much more extensive concealment. The entire story of land camouflage would overflow the confines of a volume, but it is hoped that the foregoing will aid the reader in visualizing the magnitude of the art and the scientific basis upon which terrestial camouflage is founded.

MARINE CAMOUFLAGE

At the time of the Spanish-American war our battleships were painted white apparently with little thought of attaining low visibility. Later the so-called "battleship gray" was adopted but

it has been apparent to close observers that this gray is in general too dark. Apparently it is a mixture of black and white. The ships of the British navy were at one time painted black but preceding the great war their coats were of a warm dark gray. Germany adopted dark gray before the close of the last century and Austria adopted the German gray at the outbreak of the war. The French and Italian fleets were also painted a warm gray. This development toward gray was the result of an aim toward attaining low visibility. Other changes were necessitated by submarine warfare which will be discussed later.

In the early days of unrestricted submarine warfare many schemes for modifying the appearance of vessels were submitted. Many of these were merely wild fancies with no established reasoning behind them. Here again science came to the rescue and through research and consultation, finally straightened out matters. The question of low visibility for vessels could be thoroughly studied on a laboratory scale because the seascape and natural lighting conditions could be reproduced very closely. Even the general weather conditions could be simulated although, of course, the experiments could be prosecuted out-doors with small models, as indeed they were. Lt. L. A. Jones[3] carried out an investigation on the shore of Lake Ontario, and laboratory experiments were conducted by others with the result that much light was shed on the questions of marine camouflage. This work confirmed the conclusion of the writer and others that our battleship gray was too dark. Of course, the color best adapted is that which is the best compromise for the extreme variety in lighting and weather conditions. These vary in different parts of the world so naturally, those in the war zone were of primary importance. All camouflage generally must aim to be a compromise best suited for average or dominating conditions. For example, in foggy weather a certain paint may render a ship of low visibility but on a sunny day the ship might be plainly visible. However, if ships are rendered of low visibility for even a portion of the time it is obvious that an advantage has been gained. Cloudiness increases generally from the equator northward as indicated by meteorological annals.

In order to study low visibility a scale of visibility must be established and it is essential to begin with the fundamentals of

vision. We distinguish objects by contrasts in brightness and in color and we recognize objects by these contrasts which mold their forms. In researches in vision it is customary to devise methods by which these contrasts can be varied. This is done by increasing or decreasing a veil of luminosity over the object and its surroundings and by other means. Much work has been done in past years in studying the minimum perceptible contrast and it has been found to vary with hue, with the magnitude of brightness, and with the size of the image, that is, with the distance of an object of given size. In such problems as this one much scientific work can be drawn upon. A simple, though rough, scale of visibility may be made by using a series of photographic screens of different densities. A photographic screen is slightly diffusing, still the object can be viewed through it very well. Such methods have been employed by various investigators in the study of visibility.

Owing to the curvature of the earth the distance at which a vessel can be seen on a clear day is limited by the height of the observer and of the ship's superstructure. For an observer in a certain position the visibility range varies as the square root of the distance of the object from him. Such data are easily available so they will not be given here. So far we have considered the ship itself when, as a matter of fact, on clear days the smoke cloud emitted by the ship is usually visible long before a ship's superstructure appears over the horizon. This led to the prevention of smoke by better combustion, by using smokeless fuels, etc.

The irregular skyline of a ship is perhaps one of the most influential factors which tend to increase its visibility. Many suggestions pertaining to the modification of the superstructure have been made, but these are generally impracticable. False work suffers in heavy seas and high winds.

After adopting a suitable gray as a "low-visibility" paint for ships, perhaps the next refinement was counter shading; that is, shadows were painted a lighter color, or even white. The superstructure was painted in some cases a light blue with the hope that it would fade into the distant horizon. However, the effectiveness of the submarine demanded new expedients because within its range of effectiveness no ingenuity could render its intended prey

invisible. The effective gun-fire from submarines is several miles and torpedoes can be effective at these distances. However, the submarine prefers to discharge the torpedo at ranges within a mile. It is obvious that in average weather low visibility ceased to be very effective against the submarine. The movement of a target is of much less importance in the case of gun-fire than in the case of the torpedo with its relatively low velocity. The submarine gunner must have the range, speed, and course of the target in order to fire a torpedo with any hope of a hit. Therefore, any uncertainties that could be introduced pertaining to these factors would be to the advantage of the submarine's prey. For example, low visibility gave way to confusibility in the discussions of defence against the submarine and the slogan, "A miss is as good as a mile" was adopted. The foregoing factors cannot be determined ordinarily with high accuracy so that it appeared possible to add somewhat to the difficulties of the submarine commander.

Many optical illusions have been devised and studied by scientists. In fact, some of these tricks are well known to the general reader. Straight lines may appear broken, convergent, or divergent by providing certain patterns or lines intermingled with them. Many of these were applied to models in laboratory experiments and it has been shown that confusion results as to the course of the vessel. The application of these on vessels has resulted in the grotesque patterns to be seen on ships during the latter stage of the war. It is well known that these illusions are most effective when the greatest contrasts are used, hence black and white patterns are common. Color has not been utilized as definitely as pattern in confusibility although there is a secondary aim of obtaining low visibility at a great distance by properly balancing the black, white, and other colors so that a blue-gray results at distances too great for the individual patterns to be resolved by the eye. Color could be used for the purpose of increasing the confusion by apparently altering the perspective. For example, blue and red patterns on the same surface do not usually appear at the same distance, the red appearing closer than the blue,

Such apparently grotesque patterns aimed to distort the lines of the ship and to warp the perspective by which the course

is estimated. This was the final type of marine camouflage at the close of the war. Besides relying upon these illusions, ships zigzaged on being attacked and aimed in other ways to confuse the enemy. No general attempt was made to disguise the bow because the bow-wave was generally visible. However, attempts have been made to increase it apparently and even to provide one at the stern. In fact, ingenuity was heavily drawn upon and many expedients were tried.

The convoy system is well known to the reader. This saved many vessels from destruction. Vessels of the same speed were grouped together and steamed in flocks across the Atlantic. Anyone who has had the extreme pleasure of looking down from an airplane upon these convoys led by destroyers and attended by chasers is strongly impressed with the old adage, "In unity there is strength."

Before the war began, a Brazilian battleship launched in this country was provided with a system of blue lights for use when near the enemy at night. Blue was adopted doubtless for its low range compared with light of other colors. We know that the setting sun is red because the atmospheric dust, smoke, and moisture have scattered and absorbed the blue and green rays more than the red and yellow rays. In other words the penetrating power of the red and yellow is greater than that of the blue rays. This country made use of this expedient to some extent. Of course, all other lights were extinguished and portholes were closed in ocean travel during the submarine menace.

Naturally smoke-screens were adopted as a defensive measure on sea as well as on land. Destroyers belch dense smoke from their stacks in order to screen battleships. Many types of smoke-boxes have been devised or suggested. The smoke from these is produced chemically and the apparatus must be simple and safe. If a merchantman were attacked by a submarine immediately smoke-boxes would be dumped overboard or some which were installed on deck would be put into operation and the ship would be steered in a zigzag course. These expedients were likely to render shell-fire and observations inaccurate. This mode of defence is obviously best suited to unarmed or at least to inferiorly armed vessels. In the use of smoke-boxes the direction and velocity of the wind must be considered. The writer is unac-

quainted with any attempts made to camouflage submarines under water, but that this can be done is evident from aerial observations. When looking over the water from a point not far above it as on a pier we are unable to see into the water except at points near us where our direction of vision is not very oblique to the surface of the water. The brightness of the surface of water is due to mirrored sky and clouds ordinarily. For a perfectly smooth surface of water the reflection factor is 2 per cent. for perpendicular incidence. This increases only slightly as the obliquity increases to an angle of about 60°. From this point the reflection-factor of the surface rapidly increases becoming 100 per cent. at 90° incidence. This accounts for the ease with which we can see into the water from a position directly overhead and hence the airplane has been an effective hunter of submerged marines. The depth at which an object can be seen in water depends, of course, upon its clarity. It may be surprising to many to learn that the brightness of water such as rivers, bays, and oceans, as viewed perpendicularly to its surface, is largely due to light diffused within it. This point became strikingly evident during the progress of work in aerial photometry. [4, 5]

A submerged submarine may be invisible for two reasons: (1) It may be deep enough to be effectively veiled by the luminosity of the mass of water above it (including the surface brightness) or, (2) It may be of the proper brightness and color to simulate the brightness and color of the water. It is obvious that if it were white it would have to attain concealment by submerging deeply. If it were a fairly dark greenish-blue it would be invisible at very small depths. In fact, it would be of very low visibility just below the surface of the water. By the use of the writer's data on hues and reflection-factors of earth and water areas it would be easy to camouflage submarines effectively from enemies overhead. The visibility of submarines is well exemplified by viewing large fish such as sharks from airships at low altitudes. They appear as miniature submarines dark gray or almost black amid greenish-blue surroundings. Incidentally, the color of water varies considerably from the dirty yellowish-green of shallow inland waters containing much suspended matter to the greenish-blue of deep clear ocean waters. The latter as viewed vertically are about one-half the brightness of the former under the same conditions and are decidedly bluer.

THE VISIBILITY OF AIRPLANES

In the great war the airplane made its debut in warfare and in a short time made a wonderful record, yet when hostilities ceased aerial camouflage had not been put on a scientific basis. No nation had developed this general aspect of camouflage systematically or to an extent comparable with the developments on land and sea. One of the chief difficulties was that scientific data which were applicable were lacking. During the writer's activities as Chairman of the Committee on Camouflage of the National Research Council he completed an extensive investigation of the fundamentals upon which the attainment of low visibility for airplanes must be based.[5] Solutions of the problems encountered in rendering airplanes of low visibility resulted and various recommendations were made, but the experiences and data will be drawn upon here only in a general way. In this general review details would consume too much space, for the intention has been to present a broad view of the subject of camouflage.

The visibility of airplanes presents some of the most interesting problems to be found in the development of the scientific basis for camouflage. The general problem may be subdivided according to the type of airplane, its field of operation, and its activity. For example, patrol craft which fly low over our own lines would primarily be camouflaged for low visibility as viewed by enemies above. High flying craft would be rendered of low visibility as viewed primarily by the enemy below. Airplanes for night use present other problems and the visibility of seaplanes is a distinct problem owing to the fact that the important background is the water because seaplanes are not ordinarily high flying craft. In all these considerations it will be noted that the activity of the airplanes is of primary importance because it determines the line of procedure in rendering the craft of low visibility. This aspect is too complicated to discuss thoroughly in a brief resume.

The same fundamentals of light, color, and vision apply in this field as in other fields of camouflage, but different data are required. When viewing aircraft from above, the earth is the background of most importance. Cumulus clouds on sunny days are generally at altitudes of 4,000 to 7,000 feet. Clouds are not always present and besides they are of such a different order

of brightness from that of the earth that they cannot be considered in camouflage designed for low visibility from above. In other words, the compromise in this case is to accept the earth as a background and to work on this basis. We are confronted with seasonal changes of landscape, but inasmuch as the summer landscape was of greatest importance generally, it was the dominating factor in considering low visibility from above.

On looking down upon the earth one is impressed with the definite types of areas such as cultivated fields, woods, barren ground and water. Different landscapes contain these areas in various proportions, which fact must be considered. Many thousand determinations of reflection-factor and of approximate hue were made for these types of areas, and upon the mean values, camouflage for low visibility as viewed from above was developed. A few values are given in the accompanying table but a more comprehensive presentation will be found in reference 5.

MEAN REFLECTION-FACTORS.

(From thousands of measurements made by viewing vertically downward during summer and fall from various altitudes.)

	Per cent.
Woods	4.3
Barren ground	13.0
Fields (grazing land and growing crops)	6.8
Inland water (rivers and bays)	6.8
Deep ocean water	3.5
Dense clouds	78.0

Wooded areas are the darkest general areas in a landscape and possess a very low reflection-factor. From above one sees the deep shadows interspersed among the highlights. These shadows and the trapping of light are largely responsible for the low brightness or apparent reflection-factor. This is best illustrated by means of black velvet. If a piece of cardboard is dyed with the same black dye as that used to dye the velvet it will diffusely reflect 2 or 3 per cent. of the incident light, but the black velvet will reflect no more than 0.5 per cent. The velvet fibers provide many light traps and cast many shadows which reduce the relative brightness or reflection-factor far below that

of the flat cardboard. Cultivated fields on which there are growing crops are nearly twice as bright as wooded areas, depending, of course, upon the denseness of the vegetation. Barren sun-baked lands are generally the brightest large areas in a landscape, the brightness depending upon the character of the soil. Wet soil is darker than dry soil owing to the fact that the pores are filled with water thus reducing the reflection-factor of the small particles of soil. A dry white blotting paper which reflects 75 per cent. of the incident light will reflect only about 55 per cent. when wet.

Inland waters which contain much suspended matter are about as bright as grazing land and cultivated fields. Shallow water partakes somewhat of the color and brightness of the bed, and deep ocean water is somewhat darker than wooded areas. Quiet stagnant pools or small lakes are sometimes exceedingly dark, in fact, they appear like pools of ink owing to the fact that their brightness as viewed vertically is almost entirely due to surface reflection. If it is due entirely to reflection at the surface, the brightness will be about 2 per cent. of the brightness of the zenith sky. That is, when viewing such a body of water vertically one sees an image of the zenith sky reduced in brightness to about 2 per cent.

The earth patterns were extensively studied with the result that definite conclusions were formulated pertaining to the best patterns to be used. Although it is out of the question to present a detailed discussion of this important phase in this resume, attention will be called to the manner in which the earth patterns diminish with increasing altitude.

For simplicity assume a camera lens to have a focal length equal to 10 inches, then the length x of the image of an object 100 feet long will be related to the altitude h in this manner:

$$\frac{x}{10} = \frac{100}{h} \text{ or } xh = 1{,}000.$$

By substituting the values of altitude h in the equation the values of the length x of the image are found. The following values illustrate the change in size of the image with altitude:

Altitude, h feet	Size of image x in inches
1,000	1.00
2,000	0.50
3,000	0.33
4,000	0.25
10,000	0.10
20,000	0.05

It is seen that the image diminishes less rapidly in size as the altitude increases. For example, going from 1,000 feet to 2,000 feet the image is reduced to one-half. The same reduction takes place in ascending from 10,000 to 20,000 feet. By taking a series of photographs and knowing the reduction-factor of the lens it is a simple matter to study pattern. An airplane of known dimensions can be placed in the imagination at any altitude on a photograph taken at a known altitude and the futility of certain patterns and the advantages of others are at once evident.

It is impracticable to present colored illustrations in this resumé and values expressed in numbers are meaningless to most persons, so a few general remarks will be made in closing the discussion of low visibility as viewed from above in spring, summer and fall. A black craft is of much lower visibility than a white one. White should not be used. The paints should be very dark shades. The hues are approximately the same for the earth areas as seen at the earth's surface. Inland waters are a dirty blue-green or bluish-green, and deep ocean water is a greenish-blue when viewed vertically, or nearly so. Mean hues of these were determined approximately.

Before considering other aspects of camouflage it is well to consider such features as haze, clouds and sky. There appear to be two kinds of haze which the writer will arbitrarily call earth and high haze, respectively. The former consists chiefly of dust and smoke and usually extends to an altitude of about 1 mile although it occasionally extends much higher. Its upper limit is very distinct as seen by the "false" horizon. This horizon is used more by the pilot when flying at certain altitudes than the true horizon. At the top of this haze cumulus clouds are commonly seen to be poking out like nearly submerged icebergs. The upper haze appears somewhat whiter in color and appears to extend sometimes to altitudes of several or even many

miles. The fact that the "earth" haze may be seen to end usually at about 5,000 to 6,000 feet and the upper haze to persist even beyond 20,000 feet has led the writer to apply different names for convenience. The upper limit of the "earth" haze is determined by the height of diurnal atmospheric convection. Haze aids in lowering the visibility of airplanes by providing a luminous veil but it also operates at some altitudes to increase the visibility of airplanes viewed from below by tending to increase the brightness of the sky which is the background in this case.

The sky generally decreases considerably in brightness as the observer ascends. The brightness of the sky is due to scattered light, that is, to light being reflected by particles of dust, smoke, thinly diffused clouds, etc. By making a series of measurements of the brightness of the zenith sky for various altitudes, the altitude where the earth haze ends is usually plainly distinguishable. Many observations of this character were accumulated. In some extreme cases the sky was found to be only one-tenth as bright when observed at high altitudes of 15,000 to 20,000 feet as seen from the earth's surface. This accounts partly for the decrease in the visibility of an airplane as it ascends. At 20,000 feet the sky was found to contribute as little as 4 per cent. of the total light on a horizontal plane and the extreme harshness of the lighting is very noticeable when the upper sky is cloudless and clear.

Doubtless, it has been commonly noted that airplanes are generally very dark objects as viewed from below against the sky. Even when painted white they are usually much darker than the sky. As they ascend the sky above them becomes darker, although to the observer on the ground the sky remains constant in brightness. However, in ascending, the airplane is leaving below it more and more luminous haze which acts as a veil in aiding to screen it until, when it reaches a high altitude the combination of dark sky behind it and luminous haze between it and the observer on the ground, it becomes of much lower visibility. Another factor which contributes somewhat is its diminishing size as viewed from a fixed position at the earth. The minimum perceptible contrast becomes larger as the size of the contrasting patch diminishes.

Inasmuch as there is not enough light reflected upward from the earth to illuminate the lower side of an opaque surface sufficiently to make it as bright as the sky ordinarily excepting at very high altitudes for very clear skies it is necessary, in order to attain low visibility for airplanes as viewed from below, to supply some additional illumination to the lower surfaces. Computations have shown that artificial lighting is impracticable but measurements on undoped airplane fabrics indicate that on sunny days a sufficient brightness can be obtained from direct sunlight diffused by the fabric to increase the brightness to the order of magnitude of the brightness of the sky. On overcast days an airplane will nearly always appear very much darker than the sky. That is, the brightness of the lower sides can in no other manner be made equal to that of the sky. However, low visibility can be obtained on sunny days which is an advantage over high visibility at all times as is the case with airplanes now in use. Many observations and computations of these and other factors have been made so that it is possible to predict results. Transparent media have obvious advantages, but no satisfactory ones are available at present.

Having considered low visibility of aircraft as viewed from above and from below, respectively, it is of interest to discuss briefly the possibility of attaining both of these simultaneously with a given airplane. Frankly, it is not practicable to do this. An airplane to be of low visibility against the earth background must be painted or dyed very dark shades of appropriate color and pattern. This renders it almost opaque and it will be a very dark object when viewed against the sky. If the lower surfaces of the airplane be covered with white paint or aluminum foil the airplane still remains a dark object against the blue sky and a very dark object against an overcast sky, except at high altitudes. In the latter cases the contrast is not as great as already explained. A practicable method of decreasing the visibility of airplanes at present as viewed from below is to increase the brightness by the diffuse transmission of direct sunlight on clear days. On overcast days clouds and haze must be depended upon to screen the craft.

In considering these aspects it is well to recall that the two sources of light are the sun and the sky. Assuming the sun to

contribute 80 per cent. of the total light which reaches the upper side of an opaque horizontal diffusing surface at midday at the earth and assuming the sky to be cloudless and uniform in brightness, then the brightness of the horizontal upper surface will equal 5 RB, where R is the reflection factor of the surface and B is the brightness (different in the two cases) of the sky. On a uniformly overcast day the brightness of the surface would be equal to RB. Now assuming Re to be the mean reflection-factor of the earth, then the lower side of a horizontal opaque surface suspended in the air would receive light in proportion to ReB. If this lower surface were a perfect mirror or a perfectly reflecting and diffusing surface its brightness would equal 5 ReB on the sunny day and ReB on the overcast day where B is the value (different in the two cases) of the brightness of the uniform sky. The surface can never be a perfect reflector so on an overcast day its brightness will be a fraction (RRe) of the brightness B of the uniform sky. Inasmuch as Re is a very small value, it is seen that low visibility of airplanes as viewed from below generally cannot be attained on an overcast day. It can be approached on a sunny day and even realized by adopting the expedient already mentioned. Further computations are to be found in reference 5.

Seasonable changes present no difficulties, for from a practical standpoint only summer and winter need be generally considered. If the earth is covered with snow an airplane covered completely with white or gray paint would be fairly satisfactory as viewed from above, and if a certain shade of a blue tint be applied to the lower surfaces, low visibility as viewed from below would result. The white paint would possess a reflection-factor about equal to that of snow, thus providing low visibility from above. Inasmuch as the reflection factor of snow is very high the white lower sides of an airplane would receive a great deal more light in winter than they would in summer. Obviously, a blue tint is necessary for low visibility against the sky, but color has not been primarily considered in the preceding paragraphs because the chief difficulty in achieving low visibility from below lies in obtaining brightness of the proper order of magnitude. In winter the barren ground would be approximately of the same

color and reflection-factor as in summer so it would not be difficult to take this into consideration.

Seaplanes whose backgrounds generally consist of water would be painted of the color and brightness of water with perhaps a slight mottling. The color would generally be a very dark shade approximating blue-green in hue.

Aircraft for night use would be treated in the same manner as aircraft for day use, if the moonlight is to be considered a dominant factor. This is one of the cases where the judgment must be based on actual experience. It appears that the great enemy of night raiders is the searchlight. If this is true the obvious expedient is to paint the craft a dull jet black. Experiments indicate that it is more difficult to pick up a black craft than a gray or white one and also it is more difficult to hold it in the beam of the searchlight. This can be readily proved by the use of black, gray, and white cards in the beam of an automobile headlight. The white card can be seen in the outskirts of the beam where the gray or black cannot be seen, and the gray can be picked up where the black one is invisible. The science of vision accounts for this as it does for many other questions which arise in the consideration of camouflage or low visibility.

Some attempts have been made to apply the principle of confusibility to airplanes as finally developed for vessels to circumvent the submarine, but the folly of this appears to be evident. Air battles are conducted at terrific speeds and with skilful maneuvering. Triggers are pulled without computations and the whole activity is almost lightning-like. To expect to confuse an opponent as to the course and position of the airplane is folly.

The camouflage of observation balloons has not been developed though experiments were being considered in this direction as the war closed. Inasmuch as they are low-altitude craft it appears that they would be best camouflaged for the earth as a background. Their enemies pounce down upon them from the sky so that low visibility from above seems to be the better choice.

In the foregoing it has been aimed to give the reader the general underlying principles of camouflage and low visibility, but at best this is only a resumé. In the following references will be found more extensive discussions of various phases of the subject.

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1 Concealing Coloration, by G. H. Thayer.

2 Color and its Applications, by M. Luckiesh.

3 Confidential report of The Submarine Defense Association, prepared by L. T. Bates and L. A. Jones.

4 Aerial Photometry, by M. Luckiesh, *Astrophysical Jour.*, 49, 1919, p. 108.

4 Aerial Photometry, by M. Luckiesh, *Astrophysical Jour.*, 49, 1919, p. 108; 1919, p. 289, 302.

TRANSACTIONS

OF THE

Illuminating Engineering Society

PART II -- PAPERS

VOL. XIV AUGUST 30, 1919 NO. 6

SOME PRACTICAL DAYLIGHT MEASUREMENTS IN MODERN FACTORY BUILDINGS*

BY EMILE G. PERROT AND FRANK C. VOGAN.

Illumination of buildings, particularly industrial plants, has been very thoroughly developed along the lines of artificial illumination, and great credit is due those whose labors have brought up to the high standard of perfection the means by which the illuminating engineer can with certainty predetermine a successful lighting scheme, be it for a humble home or an industrial plant involving complex lighting problems.

In the proportion that artificial lighting has been studied and perfected in this country, daylight illumination seems to have been neglected, by that we mean the practical determination of the relation of the fundamental elements entering into daylight illumination. We are fully aware that the last decade has been marked by a big advance in the kind and arrangement of windows in all types of buildings, but what we have yet to find worked out, with a definiteness that is suitable for every-day practical use, is data that will enable one to state in advance of the erection of a building just what the intensity of the daylight illumination is going to be, say on the first floor of a six-story building 60 ft. wide situated on a 60 ft. street running east and west having buildings on the opposite side 35 ft. high, and what will be the illumination on each of the floors, when the window area is a certain percentage of the floor area and the stories are a given number of feet in height and the color of the interior is known, as well as the nature of the contents and the color of the walls of the buildings opposite.

* Paper presented before the Philadelphia Section of the Illuminating Engineering Society, Philadelphia, Pa., [illegible]

With a view of obtaining some data from existing buildings to compare with the information available on the subject of daylight illumination, we have secured photometric readings in several buildings, which information forms the subject matter of this paper.

We fully realize the work is more in the nature of approximations when compared with laboratory experiments and that we have not by any means secured enough actual data to make final deductions. However, we have made a start, and are presenting it to the members of the Illuminating Engineering Society with the hope that it may inspire others to an effort along similar lines and thus create a fund of information which is now sorely needed.

Further, we are fully aware that some very successful work has been done in this line, and we refer especially to the paper by Marks and Woodwell which appeared in the TRANSACTIONS of the Illuminating Engineering Society, Vol. IX, No. 7, 1914; also the articles that have appeared in *The American Architect,* issues of February 20, 1918, and March 13, 1918, as well as the very complete treatise on "Daylight Versus Sunlight in Saw-tooth Roof Construction" by W. S. Brown, which appeared in the January 1, 1919 issue of the same magazine.

We wish also to call attention to the very excellent work entitled "Orientation of Buildings or Planning for Sunlight" by William Atkinson, which gives a complete analysis of one phase of the subject, but leaves out of consideration illumination from daylight on cloudy days. We will have occasion to refer to this work later. In England the Departmental Committee on Lighting in Factories and Workshops has issued a very complete report embodying the results obtained in quite a few factories of different types, and they have established what they call a "daylight factor" for the various buildings investigated, this factor being the ratio of the intensity of the inside illumination to the intensity of the outside illumination, the readings being taken simultaneously.

We have endeavored to verify, in buildings we have studied, the existence of such a daylight factor, for if it is found that a building of a certain type and under certain conditions has such

a factor, then a long step in advance of daylight illumination has been made.

However, we have progressed sufficiently far in our investigations to arrive at the conclusion that a "daylight factor" of a building is a very unsatisfactory term to be used in designing buildings, since one cannot be found to apply alike to the same type of building, for all seasons of the year. Furthermore, a factor that would apply under a clouded sky would not apply with a clear sky in the case of multi-storied buildings that have uni-lateral or bi-lateral lighting and are surrounded by other buildings, such as obtain in closely built up areas of cities.

For isolated buildings and those lit exclusively by saw-tooth skylight roof construction facing north, the determination of a working "daylight factor" is much simpler and more reliable.

In order to demonstrate the truth of these statements, we will show how a room 24 ft. square lighted by a single window 3 ft. 6 in. wide by 8 ft. high, with a wall thickness of 1 ft., giving a visual angle of 148° 6′ and a normal area of opening of 28 sq. ft., produces varying intensities of illumination within the rooms during the two solstices and two equinoxes of the year, first—orientated with the four sides facing the Cardinal points and then with its diagonal upon the meridian, the window having different aspects.

The illustrations and data here given are taken from Mr. Atkinson's book on the orientation of buildings above referred to, and are exhibited as showing very strikingly the part the sun plays in the interior natural illumination of buildings.

Fig. 1 shows the area of floor subject to direct sunlight for windows of different aspects; winter solstice latitude 42° 0′ north.

Fig. 2 shows the area of floor subject to direct sunlight for windows of different aspects; autumnal and vernal equinoxes latitude 42° 0′ north.

Fig. 3 shows the area of floor subject to direct sunlight for windows of different aspects; summer solstice latitude 42° 0′ north.

In order to compare the amount of sunlight admitted by windows of different aspects, Mr. Atkinson takes as a unit the quantity of sunlight which passes through an opening 1 ft. square, in

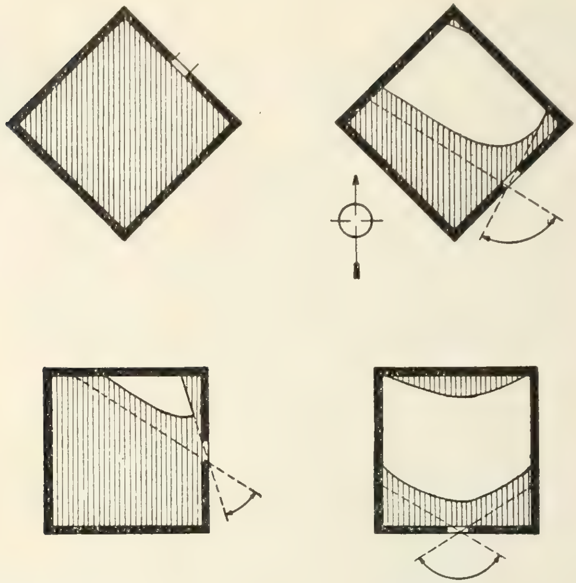


Fig. 1.—Showing the area of floor subject to direct sunlight, for windows of different aspects, winter solstice, Lat. 42°—0′ N.

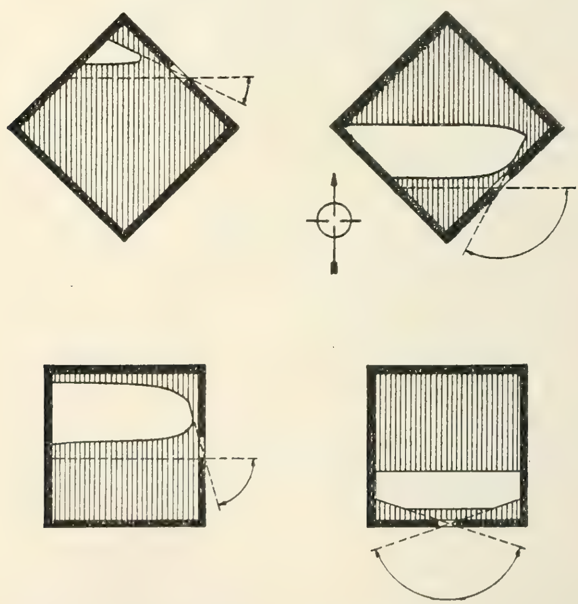


Fig. 2.—Showing the area of floor subject to direct sunlight, for windows of different aspects, autumnal and vernal equinox; Lat. 42°—0′ N.

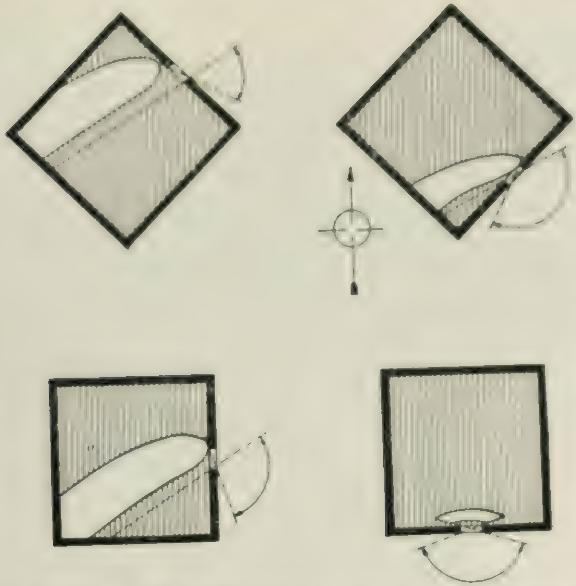


Fig. 3.—Showing area of floor subject to direct sunlight for windows of different aspects; summer solstice; Lat. 42°—0' N.

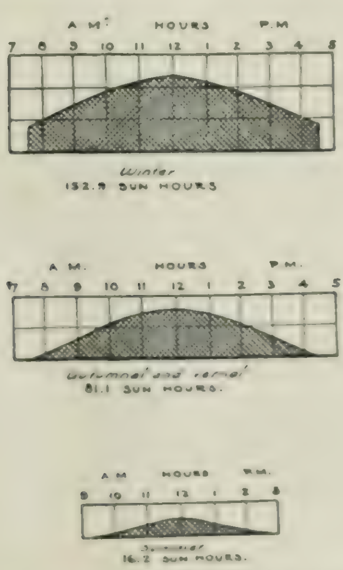
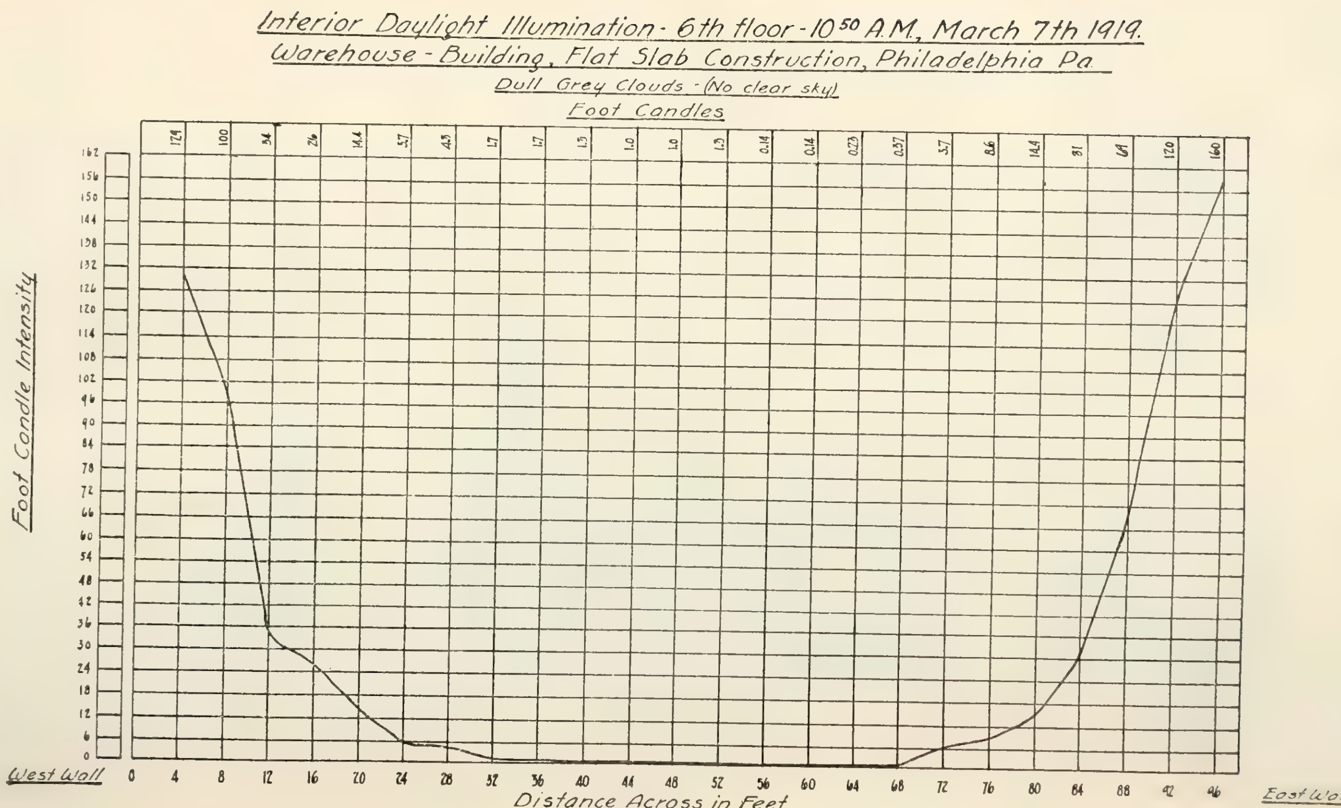


Fig. 4.—Showing relative quantities of direct sunlight admitted by a window facing south, at various equinoxes and solstices.



Interior Daylight Illumination - 6th floor - 10 50 A.M., March 7th 1919.
Warehouse - Building, Flat Slab Construction, Philadelphia Pa.
Dull Grey Clouds - (No clear sky)
Foot Candles
Foot Candle Intensity
West Wall
East Wall
Distance Across in Feet

Fig. 5.

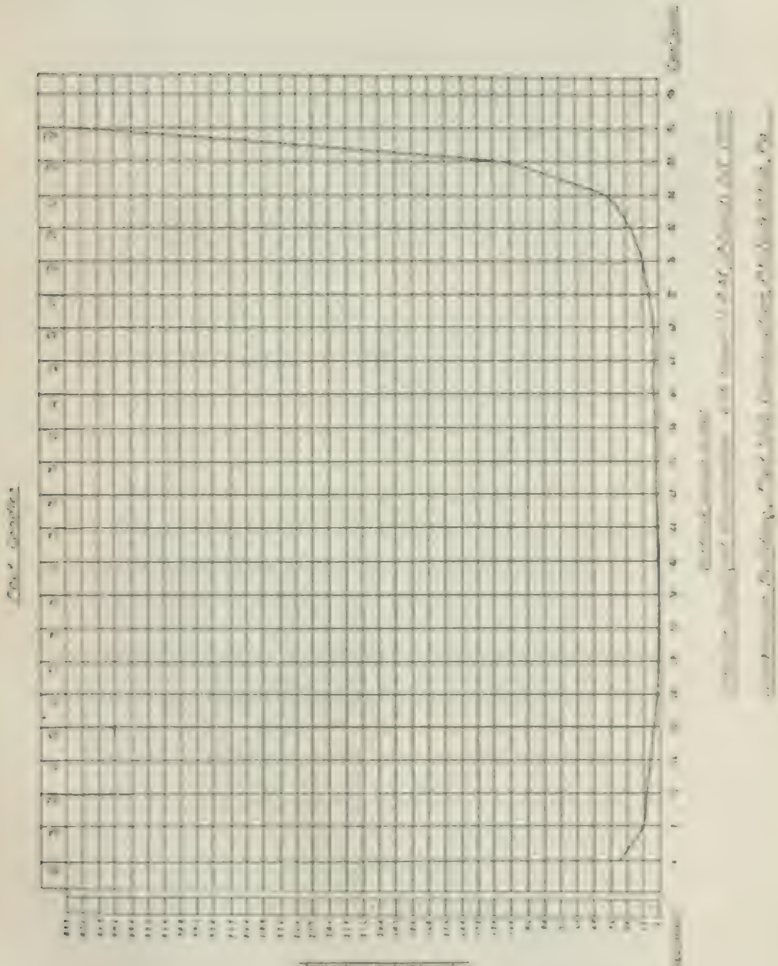


Fig 6.

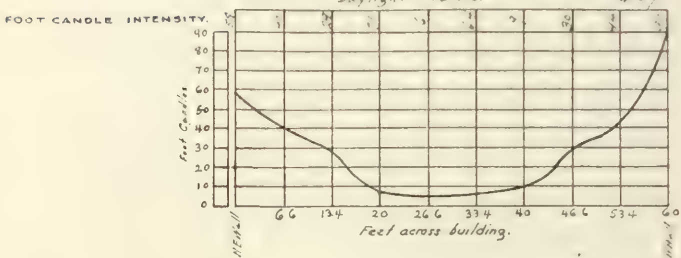
Observation in 60ft. wide, Beam and Girder Construction, Factory Building
April 11, 1919

Weather Cloudy

Floor area - 1280 sq ft. wall area each floor - 573 sq ft

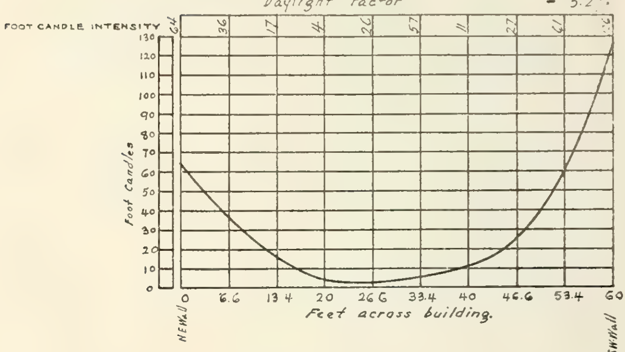
1st floor

Window Area	- 372 sq ft
Ratio Window to Floor	- 29 %
Ratio Window to Wall	- 65 %
Average Inside Illumination	- 32 F.C.
Average Outside Illumination	- 715 F.C.
Daylight Factor	- 4.5 %



2nd floor

Window Area	- 372 Sq Ft
Ratio-Window to Floor	- 29 %
Ratio-Window to Wall	- 65 %
Average Inside Illumination	- 36 FC
Average Outside Illumination	- 690 FC
Daylight Factor	- 5.2 %



3rd. Floor

Ratio Same as Second Floor.

Average Inside Illumination	- 43 F.C
Average Outside Illumination	- 615 F.C
Daylight Factor	- 7 %

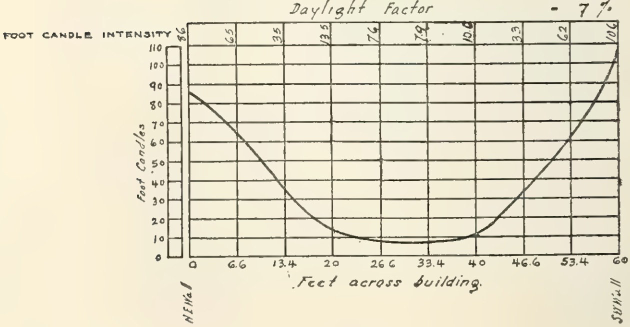
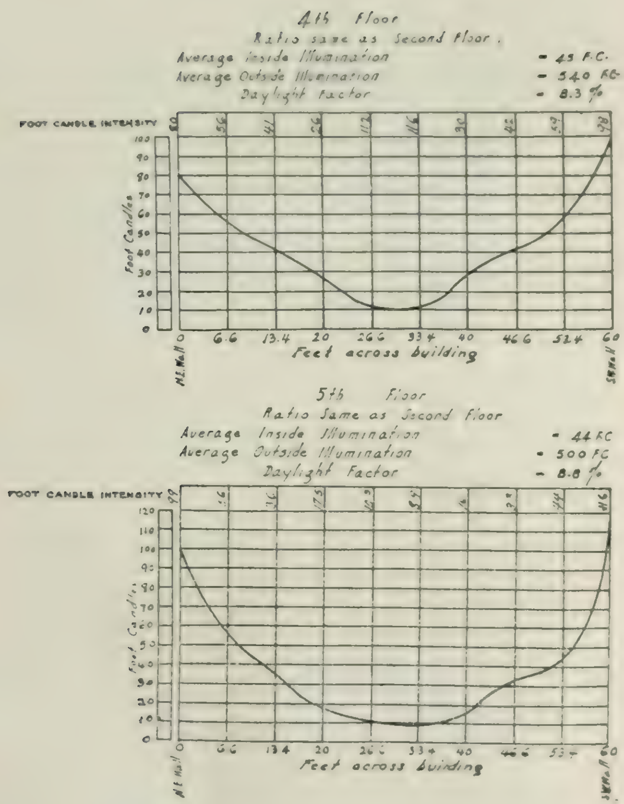


Fig. 7.



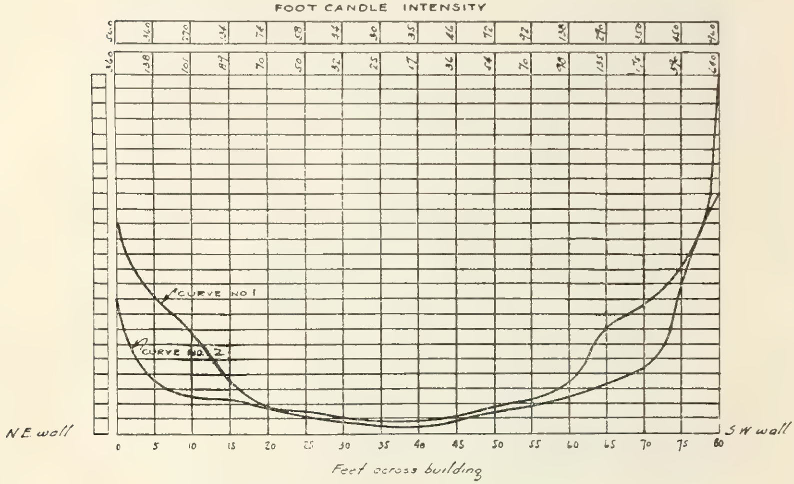
Continuation of Fig. 7.

Observations in 80 ft wide Factory Bldg. April 11th, 1919
Flat slab construction

2nd floor.
Window area = 274 ϕ, Floor area = 1570 ϕ, Wall area = 475 ϕ
Ratio window area to floor area = 274 ÷ 1570 = 17.5 %
Ratio window area to wall area = 274 ÷ 475 = 58 %

Curve No. 1 12 M, cloudy, some sun
Outside Illumination 2000 FC
Av Inside Illumination 233 FC
Daylight Factor 233 ÷ 2000 = 11.6 %

Curve No. 2 3 10 PM cloudy
Outside Illumination 1517 FC
Av Inside Illumination 146 FC
Daylight Factor = 9.7 %



4th floor. 3.40 PM, cloudy, no sun (Note - large sign on part of southwest wall)
Window area = 274 ϕ, Floor area = 1570 ϕ
Ratio Window/Floor = 17.5 %
Ratio Window/Wall = 58 %
Outside Illumination 1080 FC, Av Inside Illumination 119 FC
Daylight Factor 11.0 %

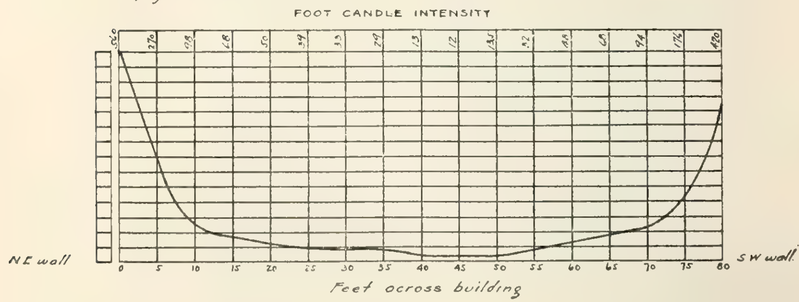
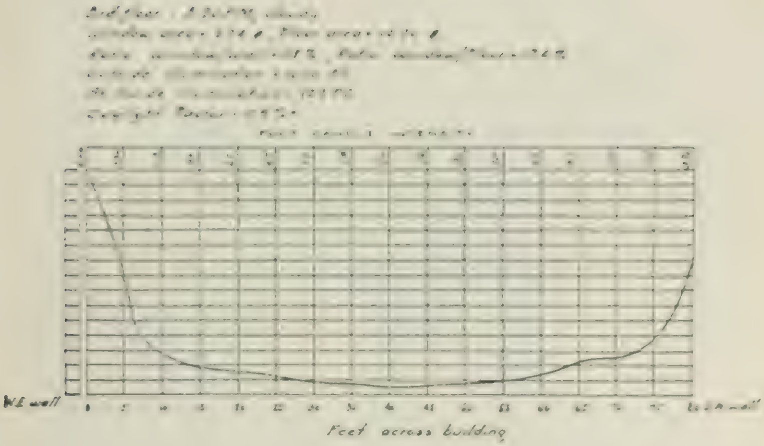
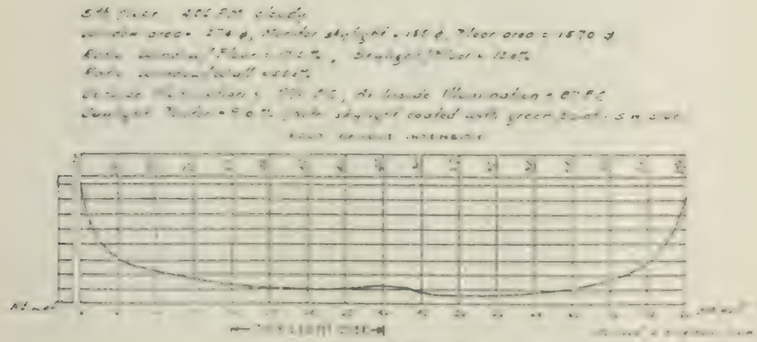


Fig. 8.





Continuation of Fig. 8

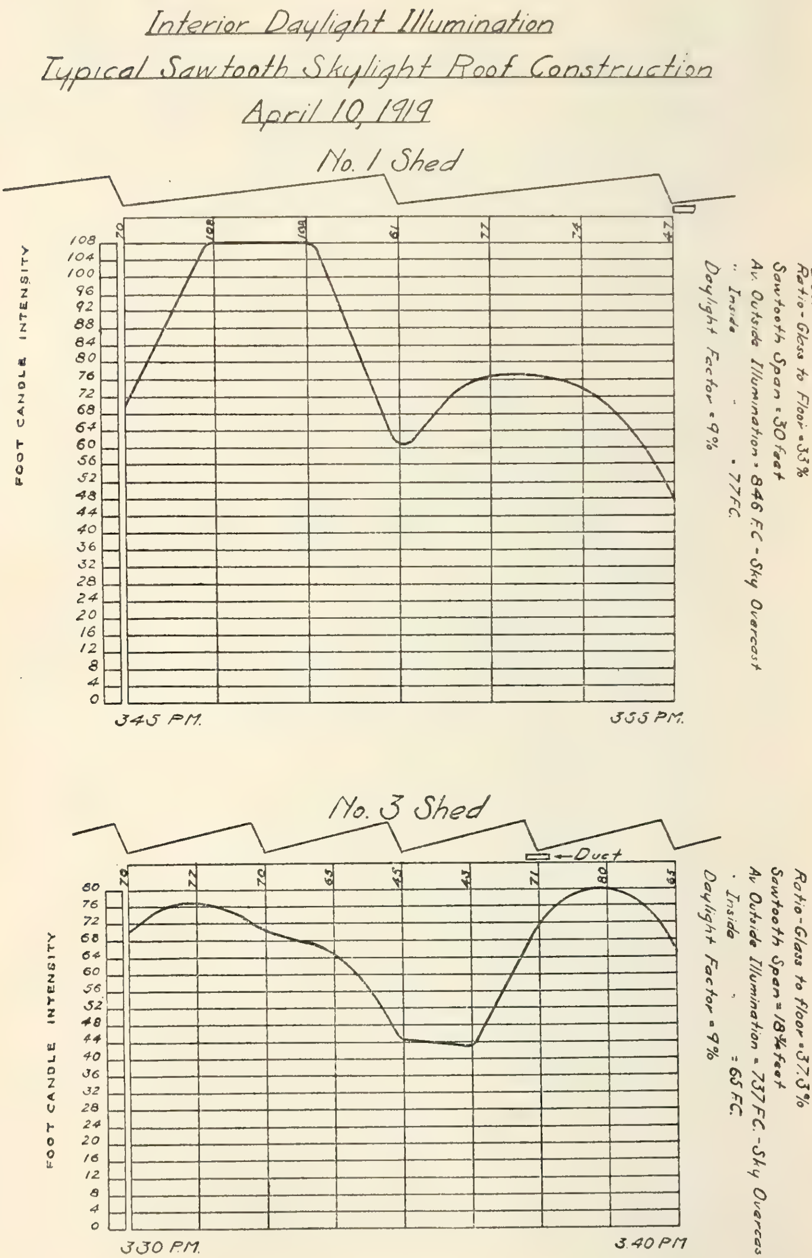
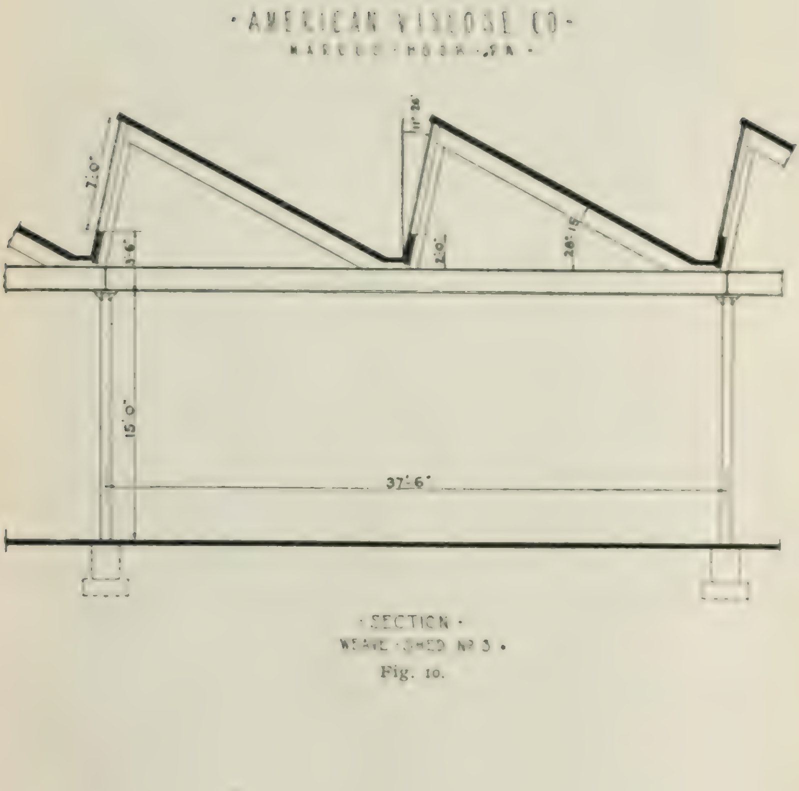

Interior Daylight Illumination
Typical Sawtooth Skylight Roof Construction
April 10, 1919
No. 1 Shed
FOOT CANDLE INTENSITY
345 P.M.
355 P.M.
Duct
Ratio-Glass to Floor = 33%
Sawtooth Span = 30 feet
Av. Outside Illumination = 846 FC - Sky Overcast
" Inside " = 77 FC.
Daylight Factor = 9%
No. 3 Shed
Duct
FOOT CANDLE INTENSITY
330 P.M.
3.40 P.M.
Ratio-Glass to floor = 37.3%
Sawtooth Span = 18¼ feet
Av. Outside Illumination = 737 FC. - Sky Overcast
" Inside " = 65 FC.
Daylight Factor = 9%

Fig. 9.



· SECTION ·
WEAVE · SHED No 3 ·

Fig. 10.

a plane normal to the sun's rays, in one hour. The areas of the figures may then be expressed in terms of this unit, which he calls a *sun hour,* as shown in Table I.

The rays of sunlight passing through any aperture as a window forms a prism, the cross section of which changes as the angle of sunlight changes, the area of the cross section of such a prism may be found by descriptive geometry.

If we calculate the areas of the prisms at intervals of one hour, these areas may be represented by the vertical lines or ordinates in the graphs or curves and the abscesses will represent the hours, and the area of the whole figure the total amount or quantity of sunlight admitted by the window during the day.

Fig. 4 shows the relative quantity of sunlight admitted by a window facing south at the winter solstice, the summer solstice, and at the equinoxes.

TABLE I.—TABLE OF WINDOW VALUES EXPRESSED IN "SUN HOURS."

	Winter solstice	Equi-noxes	Summer solstice
North	....	....	6.8
Northeast and northwest	....	18.6	73.2
East and west	32.9	82.7	110.7
Southeast and southwest	108.5	105.5	53.4
South	152.9	81.1	16.2

It will be noticed that for the winter solstice the window in question has the largest number of "sun hours" being 153 in the winter, 81 at the equinoxes and only 16 in the summer, when the days are brightest, but on account of the high altitude of the sun less direct sunlight can enter the room, so that the reflection from floor, walls and ceilings is less. It must not, however, be forgotten that the meteorological conditions are less favorable in winter than in summer, so that while the sun hours are greater in winter there are fewer days when the sky is clear as compared with the summer season, and we do not obtain the great benefit that is apparent from the curves shown herewith. Furthermore, the range of the brightness of daylight as between summer and winter may be as great as 10 to 1, so that the effect of the greatest number of sun hours in the winter would be modified.

In order to understand more fully the difficulties encountered in the investigation of daylight illumination of buildings, it will

be well for us to consider briefly the sources of daylight. There are two sources, as follows:

Primary Source—(1) Sunshine.

Secondary Source—(2) Cloud light or white skylight derived from scattered sunshine; (3) blue skylight from the air; (4) diffused light reflected or re-reflected from objects illuminated from the above sources.

There is a great variation in the intensity of daylight with different classes of sky, hence a study of sky brightness is imperative as a first consideration. We are indebted to the article published by M. Luckiesh in the March, 1919, number of the *Journal of the Franklin Institute* on the "Visibility of Airplanes" for the data relating to sky brightness, also to the Electrical Testing Laboratories of New York for valuable information on this subject.

In dealing with problems of lighting, it is necessary to distinguish between illumination and brightness (cause and effect respectively).

The unit of brightness in the lumen system is the "lambert" and is the brightness of a perfect diffusing surface emitting or reflecting 1 lumen per square centimeter. For most purposes the millilambert, 0.001 lambert, is the preferable practical unit.

A perfect diffusing surface emitting 1 lumen per square foot will have a brightness of 1.076 millilamberts. One foot-candle is 1 lumen per square foot, or 1 lambert is equivalent to 929 foot-candles.

Thousands of measurements were made by Mr. Luckiesh, numerous cross-country flights in airplanes were made, besides many short flights, or about 5,000 miles of air travel were devoted to the work.

"The illuminating intensities of sunlight and skylight on a horizontal plane presents some very interesting data. From the tests made it was found that the skylight on a clear day was only one-fifth to one-sixth as intense as the combined intensity of sunlight and skylight. In other words, during the midday the sun contributed about four or five times the amount of light that the sky contributed on this clear day. At observations high in mountains on very clear days, it has been found that as little as

one-tenth the light which reaches the earth comes from the sky, the remaining nine-tenths coming directly from the sun.

"Inasmuch as the sky is usually a prominent feature, a few facts regarding it may be of interest. Except at altitudes near that of the sun, a clear blue sky is usually considerably brighter at the lower altitudes—near the horizon—than at the zenith, due largely to the greater haziness noticeable at the lower altitudes. This is perhaps always true, excepting when dense clouds, which are not recognized as clouds, are gathering near the horizon. A clear blue sky is darker than an overcast sky except in the extreme cases of the latter. A slight haze or thin veil of clouds increases the brightness of the sky very much and, therefore, increases the amount of light which illuminates many shadows. The color of the sky when clear is more saturated than under any other condition, varying from this deep blue to the neutral gray of an overcast sky. The extreme non-uniformity of the brightness of clear blue or overcast skies is only revealed by measurement. Often a sky which appears quite uniform will vary in brightness at different points by several hundred per cent."

The following table shows the variation of the brightness of the sky in terms of millilamberts at noon and 8 a. m. of the same day, the readings being taken in two directions, east to west and north to south.

A clear sky is usually brightest at those altitudes near the sun. It is also found that north skylight is an almost constant brilliancy.

FEBRUARY 23, 1918.

11.46 a. m.

East to west	North to south
2° —2070	1460
22½°—1580	890
45° —1410	825
67½°—1300	885
90° —1480	1650
67½°—1500	3250
45° —1020	5500
22½°—1060	4120
2° —1410	4340

Sky Illumination 7850 F. C. Horizontal.

FEBRUARY 23, 1918
Clear, Weather Nearly Perfect
8:00 a. m.

East to west	North to south
2° — 5850	1280
22½° — 3170	800
45° — 1640	540
67½° — 755	475
90° — 540	465
67½° — 410	545
45° — 420	670
22½° — 755	950
2° — 990	1840

Sky Illumination 3670 F. C. Horizontal

By referring to the table it will be noticed that the brilliancy near the sun at 8 a. m. was 5,850 millilamberts, while around noontime the greatest brilliancy was 5,500 millilamberts, which was an altitude of 45°, this being nearest the sun as the readings were taken in February and the altitude of the sun, of course, not being as high as in the summer months. The increased brilliancy is due to the effect of the atmosphere or haze, which has a higher reflecting power.

At noon on clear days the illumination on a horizontal surface is due chiefly to direct sunlight. Of course, the ratio of direct sunlight to skylight at the earth's surface varies considerably owing to clouds, haze, etc., but of the total light reaching the earth's surface at noon the direct sunlight constitutes as much as 0.9 on extremely clear days. A common value is in the neighborhood of 0.8. This is assumed the total daylight illumination and is caused by hemispherical illuminating sky surface. If the sky brightness alone is represented by "B," then the total brightness, that is, direct sunlight plus sky brightness, would be "5B."

Investigations made of sky brightness by the American Luxifor Prism Co. in 1897 showed the striking fact that the actual illumination on a cloudy day with the sun overcast is about double the illumination on a perfectly clear day. This, of course, is based on omitting the effect of the sun.

CLOUDS.

Sunlit clouds are often several times brighter than an adjacent patch of blue sky, and Mr. Luckiesh found a cloud brightness of five to ten times that of the adjacent patches of clear blue sky. It

has also been found that the "dust" or low lying haze extends ordinarily to an altitude of about one mile. This haze is quite absorbing and is also fairly luminous. From data obtained, it would appear that the net result of the haze was to increase the relative brightness of the earth about 25 per cent. On very hazy days this value may be greater. One can, therefore, realize how difficult it is to obtain any very valuable data without extending the test over a long period and include measurements taken under varying meteorological conditions.

Dr. Nichols experienced, in making tests of sky illumination, that the brightness from a passing storm cloud which threatened to produce rain was the same as from the cloudless sky ten minutes before.

In studying the history of daylight illumination, one must go to England for the first effort in endeavoring to arrive at some practical solution of what might be termed "window efficiency," for in England there exist what are known as "Ancient Light Laws," which protect the owners of an existing building from damage to the light of his building to a degree below that generally obtained in the surrounding districts, and which is, in fact, a nuisance. It seems from reading the literature on this subject that there was a great deal of uncertainty in the testimony of experts in the law suits as to the actual conditions before and after the new building was erected, due to the lack of having practical scientific instruments to determine the amount of daylight admitted into the buildings. This led to the invention of photometers, which could be used for both indoor and outdoor work. D. J. Waldram, of England, published in 1908 in the *Illuminating Engineer* of London an article in which he describes such a photometer, the modification of which has since been put on the market and has been manufactured under the name of the "Luxometer." It is this instrument that we used in obtaining the data which we are presenting.

In order to make our work of some practical value in designing industrial plants, particularly the multi-storied type of buildings, such as is used for factory purposes and the saw-tooth skylight type, we have confined our efforts to investigating the daylight efficiency of several width multi-storied buildings and of several saw-tooth skylight weave sheds. The deductions here-

with presented we feel are justified by the data obtained, although it only covered certain intensities of daylight, namely, daylight resulting from an overcast sky and not from a clear sunny sky. It is, of course, agreed that daylight illumination on a cloudy day, if found to be sufficient in intensity, would be more so on a clear day. Hence we have not concerned ourselves with the daylight illumination from clear skies.

In the multi-storied buildings the foot-candle measurements were taken on each floor of the building across the room at intervals, as shown in the diagrams.

In the 100 ft. wide warehouse type of building, we have shown, for comparison, two sets of curves, one obtained from readings taken on a day when the sky was overcast and the other on a clear day. It will be noticed that the curve in the former case is almost symmetrical about the center line, while in the latter case the part of the curve representing the illumination near the windows shows a large variation in intensity of the illumination between the sunny side of the building and its shady side.

DAYLIGHT RENT VALUE FACTOR.

If we examine the graphs of the intensity of the daylight illumination at various distances across the floors of the typical 60 and 80 ft. wide multi-storied buildings, we will notice that all the curves have the same characteristics, namely, a high intensity at the windows dropping at a rather steep slope for a distance back from the windows of from 10 to 20 ft., then a more uniform illumination of lower intensity represented by a flatter slope in the interior of the building.

As in most manufacturing plants, the value of the floor space is proportional to the amount of daylight of sufficient intensity that is available for the greatest number of working hours. We have endeavored to establish a ratio which will convey at a glance what might be styled the "daylight rent value factor." This factor is obtained as follows:

The average intensity of the illumination on a plane say 3 ft. 6 in. above the floor for a distance from the wall of 20 ft. is compared with the average intensity for the rest of the interior of the room. The ratio of the mid-area illumination to the illumination of the area near the window must further be con-

pared with the mid-area floor space, as, for example, on the third floor of the 60 ft. wide building the ratio of mid-area illumination to the illumination of the area near the windows is 20 per cent. and this 20 per cent. of the maximum illumination extends for one-third the distance across the floor space. Thus there is one-third of the total floor space which is below the maximum average illumination, while in the 80 ft. wide building the ratio of mid-area illumination to the illumination near the windows is 18 per cent. and this percentage extends for one-half the distance across the floor space, there being in this case one-half the total floor space which is below the maximum average illumination. Thus the "daylight rent value factor" of the latter building is not as high as the former, and we at once have a means of comparing the daylight efficiency of the two buildings in unmistakable terms.

If we multiply the percentage of illumination by the area it affects, we obtain a constant for the floor in question which can be compared with a similar constant of another building or floor. Thus the constant for the 60 ft. wide building is 0.0667 and that of the 80 ft. wide building is 0.09, showing that the mid-area illumination (which is the least desirable) in the latter building is almost 50 per cent. greater than in the former building. To the purchaser or renter of floor space, the above analysis is of incalculable value.

60 FT. WIDE BUILDING.	80 FT. WIDE BUILDING.
Mid-area = 100% × 1/3 = 33 1/3%	Mid-area = 100% × 1/2 = 50%
0.33 1/3	0.18
0.20	0.50
0.0667 = rent value factor	0.09 = rent value factor

NOTE: Both buildings were empty when this data was obtained. Window was glaced with rough wire glass—walls and ceilings painted with mill white in a fairly clean condition.

Some very interesting data was obtained in the sheds with saw-tooth skylight roofs, and we have been able to establish the law that for a given percentage of glass in the saw-teeth in reference to the floor area, a fewer number of large scale saw-

tooth skylights give a greater interior illumination than a greater number of smaller saw-tooth skylights, as will be shown by the daylight factors in the following table.

SAW-TOOTH SKYLIGHT ROOF CONSTRUCTION

Shed No. 1—33% glass. 30 ft. span

Foot-candle readings, average inside 77
—— = daylight factor of 9%
" " outside 846

Shed No. 3—37.3% glass. 18¼ ft. span

Foot-candle readings, average inside 65
—— = daylight factor of 9%
" " " " outside 737

It will be noticed from the foregoing table that the shed with 33 per cent. of glass to the floor area had as high a daylight factor as the one with the 37.3 per cent. glass. This is an important consideration when designing a building, as it enables the designer to use the minimum amount of material with the greatest efficiency. Further, the occurrence of a less number of valleys materially would increase the light efficiency in the interior of the shed, provided the ratio of shadow to floor was reduced. However, in the case of shed No. 1 and No. 3, the ratio of shadow to floor was almost the same.

Attention is also called to the effect on light produced by the occurrence of overhead ducts. By referring to the graphs of these sheets the variation in intensity of the illumination is very evident. A study of these curves, therefore, brings out some very practical points regarding the general design of saw-tooth construction, which should be borne in mind when planning new work.

SHIPYARD LIGHTING.*

BY H. A. HORNOR.

The general problem of lighting a shipyard must naturally be based upon the design of the specific yard. Fashions in the shipbuilding industry are as pronounced as in other lines of endeavor. Historically shipyards grew by small increments. Recently, in this country large undertakings were planned and immediately put into effect. The two main designs consider solely the method of constructing a ship, *i e.*, ships built in the open or ships built under cover. In either of these cases the fabricating or manufacturing shops are not much different than the usual buildings employed by other industries, and, therefore, the lighting would show a direct similarity. For ships under construction the problem is a difficult one, unsolved at the present time, and only answered by the ingenuity of those whose duty it is to see to the lighting. It is this problem that will be considered at greater length.

From this it will be seen that the particular problem of lighting a shipyard reduces to two main sub-divisions, namely, permanent general lighting for ships under construction and what is called "temporary" or portable lighting of the ship during its building, *i. e.*, while under construction, while fitting up, and until turned over to its owners.

For ships built in the open it is necessary to have some form of transportation device or devices which shall bring the assembled material into place. There is no need to consider the various types of cranes that are available for this purpose or that have been especially designed. It is interesting to note here that one eastern yard equipped for side launching from open ways (see note at bottom of page) is provided with a specially designed gantry crane structure which spans the ship and travels longitudinally. This enables the builders to run the crane out of the way when ready to launch the ship. No matter what type of handling devices are employed they may be used to mount the permanent general lighting units for open ship

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ways. Augmenting may be done by the erection of poles with platforms sufficient to support flood light units.

This introduces one of the most difficult problems in lighting so huge an area as a ship under construction. The difficulty lies in the fact that large scaffolding has to be provided around the entire structure. This scaffolding has also to be of a temporary nature so that it may be moved along with the erection of the steel members of the ship. Again it is often in the way for some additional erections which have to be made; or when some particular work has to be done upon the structure with which the scaffolding interferes. Many trials have been made with an endeavor to locate the flood-lights between the scaffolding and the ship; or between sections of the scaffolding. The nearness of the high intensity unit, the production of broad and deep shadows, and the interference of a group of workmen not engaged upon the particular part of the structure upon which the flood-light is thrown makes this impracticable. Despite all these and many more detailed difficulties it would still seem to be a field for further investigations upon the part of the illuminating engineer.

In place of flood-lights, incandescent lights without protection have been strung in garlands and story by story along the scaffolding. As long as these small units can be conveniently swung so as to avoid obstructing the operation of the workman this method has some advantages. As in the case of temporary lighting the breakage of lamps would be naturally very heavy, but, as will be referred to later, this plays a small part in the economy of a shipyard.

In the case of designs of shipyards providing totally enclosed steel sheds, or buildings over the ship ways, the transportation of materials is naturally done by overhead travelling cranes. This allows for the location of large high intensity lighting units over the cranes. This safeguards the lighting units, gives them ready care, and easy means for renewal. In this design a number of the market type fixtures either single unit or clustered reflectors may be employed with success. It is to be remembered that the ship grows from the ground upward, therefore, high overhead lighting units must be arranged with projection methods

(Note—Pusey & Jones Shipyards at Gloucester, New Jersey.)

that will permit sufficient light intensity on the keel of the vessel and yet not produce too great an intensity when the last deck of the vessel is laid. At one time it was proposed to arrange the lighting units so they could be raised in height as the structure grew; but curiously enough, the steel ship is so erected that often very high parts of the structure will be put in place before the longitudinal members are completely assembled. This would preclude the possibility of moving lights along the sides of the building.

What is termed the "temporary" lighting of the ship under construction requires methods of installation that, while giving at all times safe and satisfactory service, must be capable of partial or complete removal with haste and without undue harm to the ship structure. The ship being made up of many small compartments and few large spaces, artificial lighting must be resorted to whether the ship is built in the open or under cover. This would mean that as far as night work on the structure is concerned there would be no augmentation in the lighting required for interior work.

The practical methods usually used for temporary lighting installations consist of some form of iron clamp which attaches to the heel of the channel beams or bulb angles. To this clamp is attached a wooden block upon which the lighting mains are placed. Wires are tapped to these mains terminating in multiple distribution plugging boards made of maple wood. From these plugging boards which are distributed throughout the vessel the individual workman can secure his portable lighting fixture.

For a great many years records were kept with an endeavor to check up the number of lamp breakages and to protect the shipbuilder from inferior lamps that might burn out in service. It was at last discovered particularly in the use of cheap grade refilled lamps that it was impossible to clearly distinguish between a broken filament or a direct burnout. From that time on no records were kept as the cost of the lamp is an insignificant economy in comparison with the cost of labor.

In plants where the distribution voltage was 220 volts many years trial was made with the use of the 220 volt incandescent lamp, both carbon and mazda. Very little precaution in the protection of the circuits was found necessary when building

ordinary coal burning vessels. With the introduction of oil burning vessels and the increased construction in this country of bulk oil steamers the temporary lighting by means of the 220 volt incandescent lamp became a serious detriment both to the safety of the workman and safety to the ship structure. This led to the introduction of 110 volt lamps for the temporary lighting, both for the lamps swung permanently in the ship as well as for portable lights. This entailed in some cases the use of a separate balancer set for each vessel under construction, or for each ship ways in the case of those yards equipped to build a number of ships on one set of ways. The reason for changing to the 110 volt lamp is obvious to the illuminating engineer as the 220 volt lamp has a very much weaker filament and has not received the development in this country comparable with the 110 volt lamp. The practical consideration of their use depends upon the commercial demands, which, in accordance with a statement issued some time ago by the engineering department of the National Lamp Works of the General Electric Company, is approximately 85 per cent. of the output of 110 volt mazda lamp factories as compared with a figure of less than 7 per cent. in the case of the 220 volt lamp.

As in other lighting problems connected with factories without the assurance of exact data, there is unquestionably an increase in production by the use of high intensity values in the temporary lighting of a ship structure. That such lighting may be carried further with even better results than are obtained to-day surrounds itself with the economic question as to the extent of the maintenance charges that are allowable for such service so as not to exceed the profits on the production work done. The practice in most of the older shipyards is to maintain the temporary lighting under a separate and distinct section of plant operation. Special men are employed to look after this work without any interfering duties. The greatest economy is obtained when the service maintains a minimum of delay in the workman's time.

SUMMARY.

There is a great deal of ingenuity displayed in the details of such lighting by the practical electrician in charge of this work. In some cases a very cheap and efficient lighting unit

has been made in the yard by the working foreman who comes in daily contact with the problems. Ordinary dishpans have served the purpose of reflectors and have offered added conveniences in the handling.

It is believed if this country now continues to produce ships at even half the yearly tonnage provided by the war program that the shipbuilding industry will grow to be one of the great manufacturing interests of the country. If this comes to pass there will be great need of the inventive powers of the illuminating engineer to solve the problem here outlined.

In 18 years the lighting methods used in shipyards have passed from sperm candles (used for temporary lighting within the last 7 years) through a period of gas lamps, beginning with the early introduction of electricity from the incandescent lamp to the early forms of series and multiple solid carbon arc lamps, passing through the development of the arc lamp up to the impregnated carbon flame arc lamp and then back to the high wattage incandescent mazda lamp. This brief review would at least substantiate the fact that the lighting of a shipyard is not an established practice and that those who build ships are not averse to improved means of lighting.

DISCUSSION.

G. H. Stickney: Shipyard lighting presents some peculiar and rather difficult problems. The nature of the work requires frequent moving of wiring and light sources. Low head room and obstructions necessitate more or less exposed locations. Available supports are subject to vibration from riveting and hammering. As a result, many of the lighting units are subject to unusually rough mechanical treatment. Even the hardiest lamps and accessories as commonly used give relatively short life.

The industry has just been through a period of feverish expansion, where rapid production was the main essential and cost a secondary consideration. No time was available for planning or installing efficient, good illumination. It was natural that under these conditions the simplest equipment, employing the cheapest form of incandescent lamps—carbon filament lamps—was used almost everywhere. The lamp breakage has been enormous, and on this account the lamp life has been very short.

We are entering a new period. From now on speed will be

less important, while economy will be necessary, if American builders are to hold their own with foreign competition.

There will still be place where the bare carbon lamp will need to be used. On the other hand, there are many places where more efficient lamps, with directing reflectors, protected by guards, flexible suspension and proper location, will not only be more economical, but what is more important, provide much better working illumination.

Conditions differ so in different yards and different parts of the yard that there is no one generalized practice which can be followed. Many practices and several types of equipment will be needed, and the selection of those will require the joint efforts of the constructors and illuminating engineers to insure good results.

I am certain that modern lamps can be so used as to have a much lower breakage than is now experienced, and by using more efficient lamps and reflectors, it will be economically practicable to provide much higher intensities and to locate the units where they will be less exposed to mechanical breakage and also, so as to require less frequent change of position.

When such changes are made and tried out it will undoubtedly develop that the gain in value of output of workmen will be greater than the entire lighting cost.

George A. Hoadley: An illuminating engineer should be kept on board a ship during its construction in order to study its requirements in illumination from every possible angle. In this way the requirements for at least one type of ship could be established and followed in future constructions.

It might be an expensive proposition but if we are to go on building ships in this country, as I believe we are, the results obtained would be of real value.

J. A. Summers: My principal experience, in the shipyards that I have helped to light, has been that the engineers were afraid of using too much light. You cannot light up a large area to a high intensity with a small amount of light, and that is what they want to do. I am speaking principally of exterior lighting, for the lighting of machine shops and other shops have

been fairly well standardized and present no special difficulty. They may be quite willing to use a watt per square foot of floor area for interior lighting, but they object to using a quarter of that in the yards and want just as high an intensity.

One of the difficulties in lighting the yards seems to be the lack of space to place poles to hang lighting units. It certainly is not practicable to place the units on the same spacing that is commonly used for interior work, but this difficulty may easily be overcome by using larger units on wider spacing. Get your lights up high enough—45 or 50 ft.—and equip them with the proper glassware and good results will follow.

At one place they could not get enough long poles. We overcame this difficulty by placing eight 1,000 watt mazda C lamps equipped with refractors on a pole and placed the poles 500 ft. apart. The results were entirely satisfactory. There were no sharp shadows and the general effect was like diffuse daylight.

The lighting of the ways is a somewhat more difficult job. The ship is surrounded by scaffolding which goes up with the ship. Here the lighting must, of necessity, be temporary and moved with the successive stages. This is a recognized condition and electricians are always available to change the wiring.

A satisfactory method of lighting the ways is to place a 100 watt lamp in an angle reflector about every 15 or 20 ft. along the scaffolding. The units should be placed to the rear of the platform in the angle formed by the next higher platform. It was found that with the lamps in this position, the breakage was not nearly as high as was anticipated. The principal breakage was found to occur when changing the wiring and very little from flying rivets.

Too much emphasis has been placed on flood-lighting in the lighting of shipyards. Flood-lighting units may be used to good advantage at places too distant to reach with the ordinary lighting units. They may be used to good advantage while laying the keel if a large wide angle unit is placed at the four corners of the ways. This is necessary so as to cut down sharp shadows and prevent a man working in his own light.

For many kinds of auxiliary lighting and protective lighting, flood-lighting units will be found to be very valuable and should find a prominent place in your lighting equipment.

H. A. Horner (in reply): I do not know that I have anything to add except to agree generally with those who have discussed the problem. You may be interested in one thought that may be outside of engineering but which I find in all my engineering work, that is, that after all we touch mostly upon human engineering. If you were to analyze all your illuminating problems just as I have frequently analyzed electrical engineering, you will find this remarkable fact that after the solution is done your problem has been one concerned with human nature.

You may be interested to know the opinion of a man who devoted himself exclusively to the Government of the United States during the war period. He said that he was unable to understand how this nation was acting after the lesson it had just received. Now those are words that are meant to sink in. His statement was to this effect, that he believed that at the opening of hostilities what this nation needed more than anything else was a lesson in *service* and that if it cost billions upon billions and the sacrifice of human life that it would pay us to go through it. In conclusion I feel that our tendency has been towards a return to what we might properly call thrift and I believe it is the bounden duty of the Illuminating Engineering Society to continue its work on these lines.

COMPUTATION OF PRECISION PHOTOMETER SCALES.

BY GORDON THOMPSON.

In laying out short photometer scales of small range, such as are employed in illumination measurements, the usual method is to compute a few of the major points and obtain the minor divisions by dividing the space between the major divisions into equal parts. The accuracy of such a scale is ample because it is better than the accuracy with which the photometric "balance" can be made. In long scales, however, the abrupt change in the width of the divisions in passing from one side to the other of the major divisions is very obvious and has an undesirable psychological effect on an observer, arousing suspicion even though the error represented by the inequality of graduation is insignificant in comparison with the unavoidable errors in the photometry. Again, when the long scales of precision photometers are to be engraved and the engraver is to make his settings with a dividing engine, it is necessary to furnish him with the values of the settings correct to better than 0.01 in.

This paper gives a simple method of accurately computing the distances for all the graduations of a photometer scale. The method is explained in considerable detail in order to facilitate its application in similar computations.

Briefly, the method consists in computing with logarithms sufficient major divisions to serve as guiding points and then filling in the intermediate points with the aid of curves of tangents.

The fundamental equation of the scale is

$$I = \frac{K}{D^2} \text{ where}$$

I = intensity of illumination
D = distance
and K = a constant.

If I is expressed in lumens and D in inches, K may be said to be the illumination corresponding to a scale setting which brings the comparison lamp 1 in. from the comparison screen.

The first step in the computation is to determine the constant. One point on the scale at a distance D_1 from the comparison screen must be taken to correspond to a scale reading of I_1. This will be spoken of hereafter as the "base." Then

$$K = I_1 D_1^2 \quad \dots \quad (1)$$

Having determined K, the distance for any value of illumination is given by

$$D = \sqrt{\frac{K}{I}} \quad \dots \quad (2)$$

Now the slope of a tangent drawn at any point on the distance-illumination scale gives the rate at which the illumination is changing with the distance (*i. e.*, with the scale reading) at that point. If D, K and I are expressed in their proper units, the numerical value of the tangent is practically equal to the width of a division at the point selected—would be exactly equal to it if the division were infinitely small.

Differentiating (*2*) with respect to I we have for the value of the slope of the tangent at any point, I,

$$\frac{dD}{dI} = -\tfrac{1}{2}\sqrt{\frac{K}{I^3}} \quad \dots \quad (3)$$

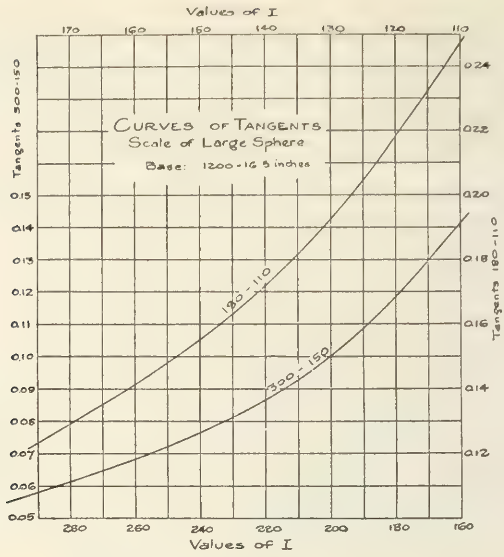
The minus sign simply means that the slope is negative, that is, the slope diminishes as I increases and *vice versa*.

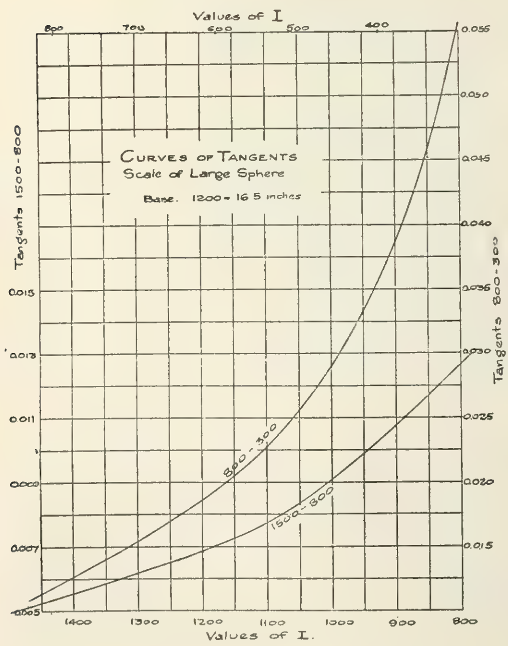
Tangents should now be computed for the major points on the I scale and plotted in curves having sufficiently extended scales to enable the computer to express the value of a division correctly to 0.001 in. a necessary extension if the value of D is to be correctly obtained to better than 0.01 in.

The remainder of the procedure is best illustrated by a concrete example.

EXAMPLE.

The example chosen is the scale of an 80-in. sphere at the Electrical Testing Laboratories. This scale is photographed on glass and the comparison lamp carriage bears a projection lamp and lens which projects an image of a narrow section of the scale on a distant ground glass. The magnification is 20 diameters so that it was especially important in this case that the minor graduations be correctly placed.


Values of I
Curves of Tangents
Scale of Large Sphere
Base: 1200-16.5 inches
Tangents 300-150
Tangents 180-110
180-110
300-150
Values of I


Values of I
Curves of Tangents
Scale of Large Sphere
Base. 1200 = 16.5 inches
Tangents 1500-800
Tangents 800-300
800-300
1500-800
Values of I.

The "base" of this scale is the length of 16.5 in. for a scale reading of 1200 lumens. Hence from (1)

$$\begin{aligned} K &= 1200 \times 16.5 \times 16.5 \\ &= 326700 \end{aligned}$$

It is convenient to express K in logarithms at once.

$$\begin{aligned} \text{Log } 1200 &= 3.079\ 181 \\ \text{Log } 16.5 &= 1.217\ 484 \\ \text{Log } 16.5 &= 1.217\ 484 \\ \hline \text{Log } K &= 5.514\ 149 \\ \text{Log } \sqrt{K} &= 2.757\ 075 \\ \text{Log } 2 &= 0.301\ 030 \\ \text{Log } \tfrac{1}{2}\sqrt{K} &= 2.256\ 045 \end{aligned}$$

The next step is to compute the major points of the scale. A general rule is to compute sufficient points, distributed along the scale, to give guide points from 2 to 3 in. apart.

The range of the scale is to be 1500 to 110 lumens. Evidently the "base" point of 1200 will be near the screen end of the scale. An estimate of the length of the scale may be made by remembering that an illumination equal to one-fourth of the "base" value will represent a point on the scale distant from the "base" point by an amount equal to the distance of the base point from the screen. Since 1200 is 16.5 in. from the screen, 300 will be 16.5 in. from 1200, and 75, if the scale were that long would be 33 in. from 300 or 49.5 in. from 1200. Hence the scale will be, very roughly, about 40 in. long and something like 21 major points between 1500 and 110 should be computed. Bearing in mind that the scale is an exponential scale and spreads out rapidly as the illumination decreases the following points were selected:

1500, 1200, 1000, 800, 700, 600, 500, 450, 400,
350, 300, 260, 230, 210, 200, 180, 160, 150,
140, 130, 120 and 110.

It is obvious that on shorter scales a smaller number of points needs to be computed.

The computations can be made with six-place logarithms, and for convenience the work should be tabulated as shown. The log of I for each value is first obtained. These logs are then divided by two to secure log $\sqrt{I}$. The results are then to be

subtracted from log $\sqrt{K}$ to secure log $\sqrt{\frac{K}{I}}$. This is most easily done by writing log $\sqrt{K}$ on a slip of paper and placing the paper directly above the value of log $\sqrt{I}$ as the subtraction is made. The anti-logs of the remainders are then secured and represent the required values of D.

It is more convenient to use a seven-place table of logarithms in which the anti-logs are given to five significant figures. Then the fifth significant figure of the value of D does not need to be computed. The seventh figure of the characteristic can be ignored throughout.

COMPUTATION OF "D."

I	Log I	Log $\sqrt{I}$	$\sqrt{\frac{K}{I}}$	D
1500	3.176 091	1.588 046	1.169 029	14.758
1200	3.079 181	1.539 590	1.217 485	16.5000
1000	3.000 000	1.500 000	1.257 075	18.071
800	2.903 090	1.451 545	1.305 530	20.2085
700	2.845 098	1.422 549	1.334 526	21.6035
600	2.778 151	1.389 076	1.367 999	23.3345
500	2.698 970	1.349 485	1.407 590	25.5615
450	2.653 213	1.326 607	1.430 468	26.944
400	2.602 060	1.301 030	1.456 045	28.580
350	2.544 068	1.272 034	1.485 041	30.552
300	2.477 121	1.238 561	1.518 514	33.000
260	2.414 973	1.207 487	1.549 588	35.448
230	2.361 728	1.180 864	1.576 211	37.689
210	2.322 219	1.161 110	1.595 965	39.443
200	2.301 030	1.150 515	1.606 560	40.417
180	2.255 273	1.127 637	1.629 438	42.603
160	2.204 120	1.102 060	1.655 015	45.187
150	2.176 091	1.088 046	1.669 029	46.669
140	2.146 128	1.073 064	1.684 011	48.307
130	2.113 943	1.056 972	1.700 103	50.130
120	2.079 181	1.039 591	1.717 484	52.178
110	2.041 393	1.020 697	1.736 378	54.498

The sum of log I and log $\sqrt{I}$ is log $\sqrt{I^3}$. Hence in the computation of the tangents, the second column of the table of computations (see below) contains these pairs of logarithms, copied from the table of computation of D, and in the third column appear the sums of these pairs, which sums represent log $\sqrt{I^3}$. As in the first table, log $\frac{1}{2}\sqrt{K}$ is written on a slip of paper and placed over each subtrahend to facilitate the subtraction. Log $\frac{1}{2}\sqrt{K}$ —Log $\sqrt{I^3}$ = Log $\frac{1}{2}\sqrt{\frac{K}{I^3}}$. The anti-logs of the remainders represent the desired tangents.

COMPUTATION OF TANGENTS

I	Log I and Log $\sqrt{I}$	Log $\sqrt{I^3}$	Log ½ $\sqrt{\frac{K}{I^3}}$	Tangent	I	Log I and Log $\sqrt{I}$	Log $\sqrt{I^3}$	Log ½ $\sqrt{\frac{K}{I^3}}$	Tangent
1500	3.176 091 1.588 046	4.761 137	$\bar{3}$.694 908	0.00495	230	2.361 728 1.180 864	3.542 592	$\bar{2}$.913 453	0.0819
1200	3.079 181 1.539 591	4.618 772	$\bar{3}$.837 273	0.00687	210	2.322 219 1.161 110	3.483 329	$\bar{2}$.972 716	0.0939
1000	3.000 000 1.500 000	4.500 000	$\bar{3}$.956 045	0.00904	200	2.301 030 1.155 515	3.456 545	$\bar{2}$.999 500	0.0999
800	2.903 090 1.451 545	4.354 645	$\bar{2}$.101 400	0.01263	180	2.255 273 1.127 637	3.382 910	$\bar{1}$.073 135	0.1183
700	2.845 098 1.422 549	4.267 647	$\bar{2}$.188 398	0.01543	160	2.204 120 1.102 060	3.306 180	$\bar{1}$.149 865	0.1412
600	2.778 151 1.389 076	4.167 227	$\bar{2}$.288 818	0.01945	150	2.176 091 1.088 046	3.264 137	$\bar{1}$.191 908	0.1556
500	2.698 970 1.349 485	4.048 455	$\bar{2}$.407 590	0.02556	140	2.146 128 1.073 064	3.219 192	$\bar{1}$.236 853	0.1725
450	2.653 213 1.326 607	3.979 820	$\bar{2}$.476 225	0.02994	130	2.113 943 1.056 972	3.170 915	$\bar{1}$.285 130	0.1928
400	2.602 060 1.301 030	3.903 090	$\bar{2}$.552 955	0.03572	120	2.079 181 1.039 591	3.118 772	$\bar{1}$.337 273	0.2174
350	2.544 068 1.272 034	3.816 102	$\bar{2}$.639 953	0.04365	110	2.041 393 1.020 697	3.062 090	$\bar{1}$.393 955	0.2477
300	2.477 121 1.238 561	3.715 682	$\bar{2}$.740 363	0.05500					
260	2.414 973 1.207 487	3.622 460	$\bar{2}$.833 585	0.06817					

Curves were now plotted of values of tangents against values of I. These are reproduced in Figs. 1 and 2. It is to be noted that it is possible to read these curves with ease to 0.0001 in. at the screen end of the scale where one division will be 10 lumens, and to 0.001 in. at the lamp end of the scale where one division will be 1 lumen.

The next step is to tabulate *all* of the divisions which are to appear on the scale. Manifestly the divisions should be sufficiently close to permit reading a setting with the same accuracy at all parts of the scale. On the other hand, it is not advisable to place the graduations closer together than say 1/16 in. Referring now to the table of tangents it would seem well to have a graduation for every 10 lumens over the range 1500-1000, every 5 lumens over the range 1000-500, every 2 lumens over the range 500-300, and every lumen for the remainder of the scale. This subdivision makes the value of a division in no case greater than 1 per cent. and permits easy estimation of ¼ per cent. and better. Full tables should now be laid out with three columns each, the first giving the values of the divisions, 1500, 1490, 1480, 1470 and so forth, the second the corresponding tangents and the third the corresponding values of D. For the example chosen these tables will contain about 450 lines.

The procedure will be shown for a section at either end of the scale. Taking first the screen end of the scale we write down graduations of 1500, 1490, 1480 and so on down to 1200, the first major, computed point after 1500. The computed values of D for these two points are written into the table. Next the tangents are to be written in for each point. Theoretically the tangents should be read off from the curves, but this would be a very tedious operation. Ample accuracy is secured if tangents are read off only at sufficiently frequent intervals to permit the assumption that the curve of tangents is a straight line between the points at which readings are actually made. It is obvious that the selected points may be farther apart at the screen end than at the lamp end.

The tangents are, therefore, read off for 1500, 1400, 1300 and 1200, and the tangents for the intermediate points are readily interpolated. Thus the tangent at 1500 is seen to be 0.0049 in.

per lumen (0.049 in. for the 10 lumen graduation). At 1400 it is 0.00545 in. per lumen. The difference is 0.00055 in. and since there are ten graduations between these two points the value of a *division* must change by 0.00055 in. for each division. Since the accuracy aimed at is not better than 0.002 in. every second tangent may be increased by 0.001 in. The same method is followed for the intervals 1400-1300 and 1300-1200.

Having all the tangents, the next step is to add progressively from 1500 = 14.758. If this is continued until 1200 is reached, the value so obtained for D at I = 1200 will be larger than the computed value. The reason is that if the third decimal place is to be correct, the fourth or even the fifth decimal place in the tangent must be correct. But this would entail a great deal of labor. The desired accuracy can be secured by working up from 1500 to 1350 and down from 1200 to 1350. By the former route 1350 = 15.552 and by the latter 15.555. The probable true value is 15.554 and the distances at the points on either side are then adjusted by tapering amounts. In the tables, the figures in the parentheses are those obtained by the addition of the tangents, while those shown in full are the probably correct values.

SAMPLE "DISTANCE" COMPUTATIONS—SCREEN END OF SCALE

I	Δ D	D		I	Δ D	D	
1500	0.049	14.758	(Comput.)	1350	0.058	15.554	(552 & 555)
1490	0.049	.807	(.807)	1340	0.059	.612	(.613)
1480	0.050	.856	(.856)	1330	0.060	.671	(.672)
1470	0.050	.906	(.906)	1320	0.060	.731	(.732)
1460	0.051	14.956	(.956)	1310	0.061	.791	(.792)
1450	0.051	15.007	(.007)	1300	0.061	.853	(.853)
1440	0.052	.058	(.058)	1290	0.062	.914	(.914)
1430	0.053	.111	(.110)	1280	0.063	15.976	(.976)
1420	0.054	.164	(.163)	1270	0.064	16.039	(.039)
1410	0.054	.218	(.217)	1260	0.064	.103	(.103)
1400	0.055	.272	(.271)	1250	0.065	.167	(.167)
1390	0.055	.327	(.326)	1240	0.066	.232	(.232)
1380	0.056	.383	(.381)	1230	0.067	.298	(.298)
1370	0.057	.440	(.438)	1220	0.067	.365	(.36[illegible])
1360	0.057	15.497	(.495)	1210	0.068	.432	(.432)
				1200	0.069	16.500	(Base)

The same procedure is followed at the other end of the scale except that the tangents must be read from the curves more frequently and a little more care taken in the adjusting. As has been indicated, one-half of an interval is covered by "working down" and the other half by "working up."

SAMPLE "DISTANCE" COMPUTATIONS —LAMP END OF SCALE

I	Δ D	D		I	Δ D	D	
140	0.1725	48.307	(Comput.)	125	0.2045	51.123	(.117 & .131)
139	0.174	.480	(.479)	124	0.207	51.329	(.335)
138	0.176	.655	(.653)	123	0.2095	51.537	(.541)
137	0.178	48.832	(.829)	122	0.212	51.748	(.751)
136	0.180	49.011	(.007)	121	0.215	51.962	(.963)
135	0.182	.192	(.187 & .200)	120	0.2175	52.178	(Comput.)
134	0.184	.375	(.382)	119	0.220	52.397	(.396)
133	0.186	.560	(.566)	118	0.223	52.619	(.616)
132	0.188	.748	(.752)	117	0.226	52.844	(.839)
131	0.190	49.938	(.940)	116	0.229	53.072	(.065)
130	0.193	50.130	(Comput.)	115	0.232	53.300	(.294 & .308)
129	0.195	.324	(.323)	114	0.235	53.533	(.540)
128	0.197	.520	(.518)	113	0.238	53.770	(.775)
127	0.200	.718	(.715)	112	0.241	54.010	(.013)
126	0.202	50.919	(.915)	111	0.244	54.252	(.254)
				110	0.2475	54.498	(Comput.)

TRANSACTIONS

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PART II -- PAPERS

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PRESIDENTIAL ADDRESS.*

BY GEORGE A. HOADLEY.

We are met, to-day, under unusual conditions. Unusual, because for the past two conventions we have been obliged to modify, to a considerable degree, our accustomed method of holding them. It may also be said that we are, fortunately, meeting under our usual conditions, since these two years are behind us and we can again take up the work of the Society, unhampered by the exigencies of a world war.

Previous to the outbreak of this war a group of men, influenced by their inborn pride, arrogance and an overestimate of their own importance, had been preparing for it. They had sedulously taught the people of their country to look upon them as supermen and to believe that it was their destiny to overrule the earth. They had zealously propagated this pretense wherever opportunity offered, they had devoted the resources of their nation to the material preparation for this war, their agriculture to raising and storing vast quantities of food, their inventors to devising, and their manufacturers to making, new and diabolical machines for destruction, and their educational interests to the dissemination of false ideals and motives.

So successful had they been in their propaganda that Might makes Right, that neighboring nations were led to join with them in an attempt to subjugate the earth and it took four years of war, requiring the sacrifice of millions of lives and billions of money to bring their dastardly efforts to naught.

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These sacrifices will not have been in vain if the nations of the earth can be brought to see that "Righteousness exalteth a nation but sin is a reproach to any people."

The lessons of this war are many and varied. One of the first to be considered is that of its injustice. Thousands of square miles in northern France and Belgium are desolate wastes. The forests, that it took a century to grow, are destroyed, the mines that required many years to develop, are ruined, the cities and villages are reduced to heaps of uninhabitable debris and the farms are unfit for cultivation.

On the other hand the land of Germany is unscarred, its forests flourish and reach out their growing branches to the sun, its cities and villages are filled with dwellings, many of which are adorned with the spoils of conquest, filched from the conquered, while its farms are everywhere covered with growing grain to provide for the coming needs.

In France and Belgium a broken and crippled few are creeping back to their old familiar haunts and with feeble efforts are trying to build for themselves the semblance of homes, while those who brought this destruction upon them are reaping bountiful crops from their undevasted fields and living lives of comparative comfort.

Another lesson to be learned is that of the uncertainty of war. The military despots who brought it about had made ample preparation. A full and complete schedule of operations had been worked out with the most careful attention to detail. Every man knew what was expected of him and, like the runner in a race, was set for the start at the crack of the pistol. But there were some things that had not been taken into account. There were those who did not think that an agreement entered into between nations could, at the convenience of either party, be considered a scrap of paper and as a result there was serious interference in carrying out the schedule on time. This delay meant a disorganization of plans for which no provision had been made and though the passage through a neutral country which was desired, was obtained by force, the delay was fatal to the successful carrying out of the plans that had been arranged. Belgium and its ruler paid dearly for their convictions but have won the admiration of the thinking world for their sturdy manliness.

Still another lesson to be learned is the value of co-operation. It was only when the allied nations placed the conduct of the war in the hands of a single leader and the commander of the forces of the United States put himself and his command unreservedly under his direction, that events began to shape themselves toward an Allied victory.

This lesson of the value of co-operation, is one that has been brought home to us in the United States with especial emphasis. When we were forced to take part in the war through the destruction of our fellow citizens on the sea, we as a nation, were totally unprepared for it. Ample warning had been given, both by the course of events and by those whose experience best fitted them to give such a warning. But our statesmen were optimistic and hoped it could be avoided while we, the people, did not want it and so we drifted on not making even the preparation that good judgment required. As a matter of fact we owe it to our allies that the fate of Belgium did not in a small measure fall upon us. A bombing airplane or a super-submarine could have brought us out of our fancied security with a decided shock.

When, however, the country once became aroused to the reality of our entrance into the war, it gave an example of the effects of enthusiastic co-operation, that will stand for many years as a proof of what can be accomplished by men who live under a republican form of government.

The readiness with which all men between certain defined ages, entered the military service of the country, was something never before witnessed. The farmer left his fields, the mechanic his tools, the merchant his goods, the lawyer his clients, the man of affairs his business and entered with a common interest and a high resolve into the business of demonstrating that the freedom which is enjoyed here should be within the reach of the smaller nations of the earth.

Older men who had retired from active service in various lines, again took up the work that would release some of the boys for service abroad.

Women trained themselves in unaccustomed pursuits, so that production should not suffer, tractors and modern implements were put upon the farms in order that the raising of wheat and other staples should be increased and manufacturers who had

formerly devoted themselves to the production of the requirements of peace, transformed their factories into shops for the making of munitions and machines of war.

Mile after mile of shipyards arose as though by magic and thousands of men turned their energies to the building of ships to supply the needs caused by the destruction of the sneaking submarine. Railroad trains loaded with men came from every direction, running toward common centers, where in a short time these men were uniformed, equipped, drilled and turned out ready for active service.

Thousands of these men were taken on shipboard every week and convoyed across the sea until more than two millions were there to do their duty on the fields of France.

This magnificent result could not have been obtained had there not been the fullest co-operation in this country on the part of every one from the leaders in great industries, requiring thousands of men and millions of money for their conduct, to those who were engaged in the humblest occupation. Each filled his own particular place in the scheme of events and was an important part of the great machine which helped so largely to bring the world war to the desired end.

Since we are a convention of the Illuminating Engineering Society it may be well to consider, briefly, what part of the Society had in the accomplishment of this great work.

In the first place I will say that there were one hundred and one members of the Society who were in active military service and of these four made the supreme sacrifice. These men, however, did not go as members of this Society but as individuals, but they indicate the quality of the service rendered by those who make up the membership of the Society.

There was, however, a great deal of work done by the Committee on War Service for which the Society was responsible and for the success of which it should receive recognition.

This Committee was appointed by President Serrill and reappointed by President Stickney.

At the beginning of the present year a change was made in the composition of the Committee, which was expected to aid in accomplishing its work more readily. This change consisted in selecting a few members from which to form an executive com-

mittee, retaining Mr. Preston S. Millar as its chairman and making each member of the Society a member of the Committee on War Service.

Under this arrangement it was understood that each member would be at the call of the chairman for such assistance as he was especially fitted to render and thus make the Society directly serviceable to the Government whenever its services were required.

Shortly after this change was made the Armistice was declared and the work of the Committee was practically at an end.

A detailed report of the work performed by the Committee was made by its chairman to the Council of the Society and brings out in full the efficient aid that was rendered.

Each problem presented was placed in the hands of a special committee for solution and the men who composed these committees deserve the thanks of the Society for the credit conferred upon it for their work.

It has seemed to me that this convention is the time to call attention to some of the problems undertaken and solved. The full report gives the names of the members of all committees. I shall undertake to give the problems only.

The names of forty-three of our members are on the lists as members of the various committees selected by the Committee on War Service and as we would expect their names are very familiar to those who are interested in lighting problems.

The following are some of the problems that were submitted to the Committee and acted upon:

Design of Lighting of Buildings for Aviation Training Camps.
Lighting of Aviation Training Camps for Traffic and Patrol Purposes.
Design of Lighting for Prospective Dirigible Balloon Hanger and Grounds.
Design of Lighting for New Navy Department Gun and Machine Shops.
Design of Protective Lighting for Portions of the Aviation Training Camp at McCook Field, Dayton, Ohio.
Design of Protective Lighting for American University, Washington, D. C.
Pamphlet on Protective Lighting.
Co-operation in Design and Construction of Lighting for Night Flying at Ellington Field, Texas.

Lighting Plans for Buildings, Ranges, etc., of Aberdeen Proving Grounds.

Vicé of Plan for Protective Lighting of Quartermaster's Store at South Boston, Mass.

Report on Device for Protection of Lamp Filaments on Battleships.

Wartime Lighting Economies.

Factory Lighting Economies.

Low Wartime Levels of Illumination Intensity.

Opinion on Proposed Hotel Lighting Restrictions.

Design of Lighting for Government Workmen's Cottages.

Metal Conservation in Reflectors.

Recommendations for Lighting Bituminous Coal Mines.

The foregoing list discloses the wide range of subjects that came before the Committee for consideration.

Reports to Government authorities were made in every case and letters acknowledging these reports were received from them. A quotation from one of these letters will show how greatly the reports were appreciated.

In acknowledging the report on Wartime Lighting Economies, G. N. Allen, Acting Director of Conservation of the United States Fuel Administration, writes as follows: "The Committee's methods of conserving fuel through proper lighting as covered in this paper, are and will be of material assistance to the various departments here. We thank you and your Committee for presenting this paper.

"We know the spirit in which it has been prepared, and we wish to ask you, your War Service Committee, and all the members of your Society, to accept the appreciation of the Administration for the service which it has rendered.

"The co-operation of the members of your Society in conservation measures assures us of a considerable fuel saving, which brings us nearer to the end of the war."

While the war has been brought to a close and business and society are trying to re-establish themselves on a peace basis, the conditions are such that it is found to be a work of some difficulty.

The wasteful expenditures caused by the efforts made to push the preparation to the fullest extent in the shortest time, have not only left a legacy of greatly increased taxation but they have accustomed us to deal lavishly and have brought about an era of high prices and expensive living.

In common with other scientific and technical societies the Illuminating Engineering Society has to face this condition and its members should co-operate with those of other societies in correcting it.

No condition can be permanently good for the country which is good for a class, or a group of its citizens alone.

High prices for the necessities of life may be good, or at least not oppressive, for the man who has profited by the business activities of the war, or for the man who is receiving a compensation for his work that is far in excess of its value, but it is a real hardship for the man who has previously been living with a fair degree of comfort, as well as for the woman whose income is limited by the returns from investments made through years of careful saving.

The attempts to make expenditure and income meet on a common basis remind one of the clumsy efforts of a puppy who is chasing its own tail. There is a great deal of motion but no real progress. Prices of commodities have been pushed up and then the workman has demanded more for his labor in order to be able to purchase and these two conditions have been recurring with increasing frequency, until there is a danger, if not a hope, that at last some one will see that a method of this kind gets nowhere and that the way to reduce the cost of an article is so to increase its production that there will be enough for all who can pay, even a reasonable price.

How can the Illuminating Engineering Society Help to Increase Production?—By changing the present wasteful and inefficient systems of lighting in use in so many factories into those that are really good. This will help in two ways, by making the cost to the factory owner less and by bringing about the ability to do more work, and more satisfactory work, under the improved conditions.

That this is possible has been proved repeatedly and it is the duty and privilege of every member of this Society to help to bring about these improved conditions whenever possible.

To do this will need the co-operation of those who are working all along the line, from the scientist who, through his researches, determines the kind of light source that will give the greatest return for the investment, to the electrician or the gas man who installs the light.

In one sense the two years of war in which we have been engaged have done more to clarify the relation between man and man than many years of peace.

During these years of peace there had grown up a feeling on the part of the laborer, or mechanic, or farmer that the man of means was a kind of excressence on the face of the earth, that he was to be endured simply because he was here and not because he was of any especial use in the scheme of things.

He could dress well and play well and spend well and his money was useful in keeping the factories at work and in giving employment to those who needed it, but as for working himself, such a thing could not be imagined.

This same man of means on his part, looked upon the laboring man, in whatever branch of labor he might be employed, as a part of the necessary cause of his being able to keep the factory running and to get the ability to dress well and play well and spend well. A man who wore ill-fitting and worn clothes and who was devoid of the finer sentiments that help so much in successful living.

But the war threw these two men into the same camp, the same tent and the same trench. The one found to his great surprise that his comrade could work with his hands as well as he, and the other that his buddy was a man of fine feeling and instinctively a gentleman.

They learned to have for each other a real respect and founded a friendship that will be a blessing whenever the time comes to put upon a firm basis what is called the relation between capital and labor.

They have learned to know that the lasting settlement of this relation must be founded upon the square deal. The one has learned that the man of means who risks his money in a business venture, or a manufacturing enterprise, runs a real risk and with the business takes upon himself the burden of the responsibility, not only of keeping it in a healthy condition, in order to give him a fair return for the capital invested, but also in order to enable him to give employment to his workmen, both when the call for his product is active, enabling him to sell quickly at a fair profit, and to provide his workmen with work when business is slack and the goods made are being piled up in the storehouse.

They have also learned that the workman has a right to expect such wages as will enable him to live in comfort and give to his family the conveniences to which self respecting American citizens are entitled.

The era of peace which is before us, even if it shall not prove to be permanent for the world, should last through the present generation, for it is evident that no man who has had a part in this war will ever wish to take part in another.

This era will have many problems that are new in fact but more that are old problems in a new form.

These problems will have to be solved by thinking men, such men as compose the major part of the membership of scientific and technical societies.

The Illuminating Engineering Society will be called upon to share in this work and if the records of the past are to be depended on, its work will be well done.

The fundamental purpose of this Society is to teach the people of this country the necessity for good lighting. This may not sound very inspiring to those who do not know the difference between good lighting and bad, but to those who have studied the matter and know the influence proper illumination has upon the mental and moral attitude of those who make use of it, it is a matter of the greatest importance.

Good lighting has as its foundation the work done in research laboratories. Research, having its beginning in the poorly equipped laboratory of science teachers in colleges and universities and carried on by some man, filled with enthusiasm for his subject but burdened by continuous and endless class work, has at last come into its own and is being carried on, not only by colleges and universities with the aid of extended facilities but by industrial corporations for the betterment and development of their production and by laboratories established solely for testing and investigation.

The men in charge of these laboratories are trained men. They come to their work with the high purpose of finding the truth by proving it.

They bring their enthusiasm with them to the work and are repaid if they can make discoveries that shall be a help to mankind.

Recall the improvements that have been made in the past 10 years in the facilities for illumination and we will see that but a small part of these would have been made if it had not been for the work of the research man.

There is a certain difference between the research man of to-day and of twenty years ago. Then he was usually content to establish a principle, to prove the truth or falsity of the claim that was being examined. To-day, he not only proves, through his researches what can be done but immediately proceeds to show how it can be done and builds the device that makes it practical.

It then comes into the hands of the manufacturer who builds the machinery for its profitable production and from him passes to the commercial house from which it is distributed to the user.

Every man connected with the production of a source of light, the investigator who carries on the research, the manufacturer of the lamp and of the glass ware, the dealer in lighting accessories, the contractor who wires or pipes our buildings, the architect who designs them and the ophthalmologist who may be called upon to correct the effects of mistakes that have been made, should all be members of this Society. Each has an important part in the ultimate results and should take advantage of the cordial co-operation which membership in the Society insures.

The co-operation between the members of the Society should be extended to include a broader co-operation between the Society and other agencies doing similar work.

An important part of the business of both the American Gas institute and the National Electric Light Association has to do with the production of light.

I bespeak the hearty co-operation of our Society with both these and other agencies that are concerned in the production of light sources.

Each of these agencies devotes itself to a special field of the lighting industry.

The Illuminating Engineering Society devotes itself to no industry but is interested solely in the discovery and improvement of light sources and the proper method of the distribution and the use of light.

The strenuous work of the war is over. Its gloomy days are past. The future extends to us inviting hands. Let us greet it with confidence and faith, firm in our desire to grasp its opportunities and strong in our determination to reap its rewards.

With such an outlook, with an increasing membership and under the enthusiastic leadership of President Doane, the Illuminating Engineering Society should enjoy a year of unexampled prosperity.

ABSTRACT—INDUSTRIAL LIGHTING AND ITS RELATION TO THE WAR.*

BY C. E. CLEWELL.

In this paper the author touched upon a number of the important relations which existed between the conduct of the war industries and factory lighting. It so happened that the paper was presented on the evening of the day following the signing of the armistice, and on this account it was pointed out that most of the items treated in the paper, although originally intended as references to war conditions, might properly be looked upon as of equal importance to the reconstruction period that was commonly expected immediately following the war. Quotations were made in this connection from statements recently found in the press to the effect that even with the end of the war there was to be no reduction immediately in the activities of the four principal non-military war agencies, namely, the War Industries Board, the War Trade Board and the Food and Fuel Administrations.

The author pointed out the great importance which lighting had had upon production in the war emergency in some of the industries, and outlined briefly the plan whereby one Section of the War Industries Board had undertaken the accumulation of data on natural and artificial lighting as an aid in its efforts to train employment managers and thereby to contribute to the reduction of the serious labor turn-over.

Lighting, besides serving to aid production, was shown to have had a special place in many of the war industries as a protective measure about the buildings and approaches, and mention was made of the attention which had been given in some lines to the question of emergency lighting within plants as a safeguard against accident and panic in case the regular lighting was extinguished and no provision made for alternative lighting.

The author commented very favorably upon the response to the requests for data as an aid to the Section of the War Industries Board which had been particularly interested in the lighting prob-

* Paper presented at a joint meeting of the Western Society of Engineers, the Chicago Section of the American Institute of Electrical Engineers, and the Chicago Section of the Illuminating Engineering Society, in Chicago, on November 12, 1919.

lem, and referred to the large amount of data which had resulted from a careful canvass of the field during the progress of the war.

In the illustrations which had been especially prepared for the paper, and which had been based largely on the canvass made under the supervision of the above mentioned Section of the War Industries Board, many of the points referred to in the paper were amplified.

In dealing with the natural lighting of factory buildings the quick industrial construction advocated by some of the firms handling such designs was pointed out in its relation to the needs, during the war, of buildings which were rushed to completion because of the urgency of war work. The adequacy of these designs as far as natural lighting was concerned, was mentioned.

In relation of the types of glass commonly employed for window lighting, a reference was made to the high percentage of light transmission which can be realized with certain forms of glass, in comparison with the ordinary allowance of ninety per cent. transmission which is sometimes assigned to the transmission of the normal component of the light incident upon window surfaces. This transmission factor is as high as 99 per cent. in certain special forms of glass. It is safe to assume, however, that in average factory practice where cleaning is not always given systematic attention, the percentage of transmission through windows into the factory interiors is quite low. This illustrates forcibly the importance of regular cleaning, which has been adopted in some of the better regulated plants.

The author took occasion to point out that the illuminating engineer in his approach of the industrial problem has more to do than merely to make a design and to determine the type of lamps and auxiliaries to install. His province can well be increased to include the selling of the idea that plenty of light contributes to production and prevents accidents. The former is a point which should appeal to every manager, while the latter should appeal to the head of every factory welfare department.

Considerable space was devoted to the needs for artificial light under day conditions where the daylight is not adequate, and this feature was commented upon in a very interesting manner by some of those who discussed the paper.

Following the paper various manufacturers and central station men discussed the paper at length and Mr. Wm. A. Durgin commented on the economic side of the question in an interesting way. The extent of this discussion as indicating the importance with which the problem was viewed by those present at the meeting, involved about fifteen pages of typewritten manuscript.

NOTE: This paper is to be published in the *Journal* of the Western Society of Engineers, but up to date has not been issued.

ABSTRACT—INDUSTRIAL LIGHTING.*

BY C. E. CLEWELL.

This paper was a comprehensive treatment of the scope of the industrial lighting field with particular reference to the details of the work involved in the plans for industrial lighting systems. Emphasis was placed at the outset upon the economic aspects of the subject with a general statement that a loss of one minute per eight-hour day for every working man in the industries of this country due to inadequate working facilities, might approximately be set down as the equivalent of a loss of $10,000,000 per annum. A similar loss equal to one hour per day out of every working day for the employees of the country would involve well on towards a half billion dollars per annum.

The magnitude of such losses when applied generally throughout the industrial centres of the nation was then shown to be related in many respects to the lighting facilities under which work is performed, and the loss of a minute or an hour per day due to inadequate light in the industries is thus more apparent when consideration is given to the total employees and the total working time involved in every branch of industry.

Attention was directed to the close correspondence which has existed during the past few years in the developments in the gas and electric lighting fields and also between the apparent similarity that has existed in the efforts to improve both natural and artificial lighting facilities in the industries. The numerous causes which have led to a study of industrial lighting and the influences which have contributed to the developments of lighting appliances particularly adapted to factory lighting were discussed, with notes on the reasons why factory managements have gradually devoted more attention to improvements in the environment under which work is performed.

The author advocated strongly the substitution of engineering methods in plans for new lighting systems rather than the continuance of the older "rule of thumb" methods which have pre-

* Paper presented at a joint meeting of the Section of Physics and Chemistry of the Franklin Institute of Pennsylvania and the Philadelphia Section, Illuminating Engineering Society, held Thursday, February 6, 1919.

vailed so generally in the past. In this connection considerable space was devoted in the paper to a discussion of many of the items which form a part of the work of the illuminating engineer in handling the industrial lighting problem, but which are sometimes overlooked by the management of a plant where the importance of the lighting work is undervalued.

The responsibility of the shop electrical department was shown to be quite a factor in the proper lighting of many factories and it was pointed out that where proper attention is given to the subject by such departments they are often capable of accomplishing good results. This would naturally be rather more pronounced in those plants where the original plans have been formulated with the help of expert assistance and where the electrical department has received instruction and guidance along well defined lines.

Brief reference was made to the part played by lighting during the war in the war industries which led to a discussion of some of the relations of good light to production, and the now fairly well established practice of analyzing lighting costs in terms of wages. This form of analysis was shown to have been strengthened by the recent tests in the Chicago district and fully reported in an earlier paper by Wm. A. Durgin.

The accident rate in winter months was mentioned in its probable relation to inadequately lighted work spaces, and several references were made to the important contributions along these lines by R. E. Simpson.

Some of the engineering details involved in plans for natural lighting were then discussed at length, with references to the problem in multiple story building, the light transmitted through various types of window glass, the reflections from opposite building fronts, and the daylight factor.

Following the outlines relating specifically to natural lighting, the author devoted considerable space to a corresponding treatment of the problem of artificial lighting, in which the types of lamps now available received first attention. This was followed by a treatment of modern reflectors and fixtures for use with Mazda lamps under industrial conditions, and notes on the use of mercury vapor lamps in some important industries.

In the remainder of the paper, the following topics were successively discussed: The overhead versus the localized system of lighting, intensities commonly employed and their relationship to daylight intensities of illumination, intensity standards, safety standards of intensity, distribution and glare, maintenance, state regulations, problems added by the war and a brief summary of the object which had been kept in view in the preparation of the paper, namely, to present a general outline of the factors involved in the industrial lighting field rather than an analysis on a scientific basis.

NOTE: The paper on which the foregoing abstract has been based was printed in full in the *Journal* of the Franklin Institute for July 1919 and covers about 40 pages with 18 illustrations.

TRANSACTIONS
OF THE
Illuminating Engineering Society
PART II -- PAPERS

VOL. XIV | NOVEMBER 20, 1919 | No. 8

REPORT OF THE COMMITTEE ON PROGRESS.*

INTRODUCTION.

"A thrifty old lady of Hull,
Whose intellect seemed rather dull,
When reading one night
To economize light,
Put luminous paint on her skull."

—*Punch.*

The abrupt termination of the world war shortly after the presentation of last year's report, brought to a close an era during which the efforts of the peoples of the whole world, east and west, were so focused on the settlement of universal progress that little attention was given to local developments. The necessary co-operation and inter-relationship brought about by the war resulted in an interchange of progress in ideas almost as fast as they were formulated. It was natural that during such times every energy should be concentrated in the production and supply of material and in developing those instruments and methods which would be of assistance in bringing victory and peace. In looking over this year's report, it may be noticed that striking changes in either the sources of light or their applications are few; on the other hand, progress in public appreciation of both industrial and civic illumination has probably never been exceeded.

In looking up some historical[1] data, a writer has observed that during the past hundred years, the average American family has not departed widely from an expenditure of twenty-four dollars

* Report prepared for presentation before the Thirteenth Annual Convention of the Illuminating Engineering Society, Oct. 20 to 23, 1919, Chicago, Ill.

The papers and discussions included in our own TRANSACTIONS are not, in general, referred to in this Report, it being taken for granted that members keep themselves advised of the contents of the TRANSACTIONS.

[1] *Jour. of Elec.*, Mar. 1, 1919, p. 226.

a year for light, and is, therefore, spending the same now as was spent a century ago. But at the present time, this family is securing more than twenty times as much light for the money.

In a review of conditions in England,[2] at the beginning of the year, the following points were brought out: that the diminution of street lighting due to war times which reached a minimum in 1918 had ceased and resulted in the beneficial effect of confirming the importance of good lighting on thoroughfares; that enforced economy had led to a closer study of the subject of illumination; that the war had driven home the necessity of co-operation and joint action, and that there are a number of cases where international co-operation will be necessary, for instance, the provision of lighting to facilitate air travel by night and, again, the requirement of good industrial illumination as one of the demands of the International Labor Conference. In Italy, a plea has been[3] made for proper courses of instruction in illuminating engineering at all the technical schools in just the same way as instruction is given in such subjects as telephony, telegraphy, etc. Interest in improved school lighting[4] in this country is shown in an investigation carried on at the request of the Trustees of the Board of Education of Chicago by an illuminating engineer of the federal government. At this year's annual convention of the National Electric Light Association there was presented by the Lamp Committee with the co-operation of the Lighting Sales Bureau of the Commercial Section an exhibit intended not only to cover all successful equipment now available for every sort of out-door and in-door lighting, but also to demonstrate the proper utilization of the in-door equipment. The latter was accomplished by a series of sections showing shop lighting, store-window lighting and home lighting. These were supplemented by an educational section showing central-station lamp practice, an out-door equipment section and one for in-door equipment as well as a section for newer lamp applications. Further reference to this exhibit will be found under appropriate headings.

It is suggested that the reaction from the restricted[5] lighting which war conditions compelled, either from the necessity of

[2] *Ill. Eng.* (Lond.), Jan. 1919, p. 1.
[3] *Ibid*, p. 16
[4] *Elec. Rev.* (U. S.), Nov. 2, 1918, p. 689.
[5] *Am. Gas Eng. Jour.*, Feb. 1, 1919, p. 89.

saving or conservation, will be in the direction of a demand for a higher standard of illumination, both in-doors and out. The results of higher illumination intensities[6] in increasing factory production, as reported to this Society, are being recognized as evidence of the necessity for increasing the foot-candle values ordinarily considered satisfactory for this class of lighting. The Inspector of Factories in British Columbia[7] has called attention to the desirability of better industrial lighting, and, that in many cases such as saw-mills where electric generators are part of the equipment, the lighting is so inadequate that the inspector has had to be furnished with a lantern in order to see well enough to perform his duties.

It is hoped that the record of improvement presented in this report will serve as a permanent stimulus to future progress and development. The committee desires to express thanks to those who have furnished data and to the publishers whose periodicals have been freely consulted.

Respectfully submitted,

FRANCIS E. CADY, *Chairman;*
W. B. LANCASTER,
F. R. MISTERSKY,
T. W. ROLPH,
W. E. SAUNDERS.

SUBJECTS

6 *Elec. Rev.* (U. S.), May 17, [illegible], pp. [illegible].
7 *Elec. News* (Can.), Apr. 1, [illegible], p. 31.

GAS.

To meet the exigencies of war times, there was formed[8] in Great Britain what was called the "National Gas Council." This body represented the interests of the various units of the industry in all matters connected with the governmental authorities. It has been reconstructed so as to make it a more fully representative body, the first components of which were part of the old incorporated bodies, the Institution of Gas Engineers, the British Commercial Gas Association and the Gas Company's Protective Association. It is hoped that this co-ordination of effort will be a great source of aid to the industry as a whole.

Not many cities have historical grounds for celebrating a centenary of gas lighting, and it is unfortunate that the appropriate date for such a celebration in Glasgow, Scotland,[9] occurred when the city was laboring under war-time restrictions and the public lighting had reverted to the oil-lamp period. It was on Sept. 15, 1818, that the streets of this city were first lighted by gas, this, it is claimed, being the first official recognition of Murdock's invention. It has been estimated[10] that in England, the mother of the gas industry, about 35 per cent. is used for lighting, 55 per cent. for heating and 10 per cent. for power.

Manufacture.—A report has been issued[11] of some tests on the production of gas from Hungarian "Totis" lignite. After its purification, the yield per 100 kilos was 34.3 cu. m. with a gross heating value of 5,950 calories and an illuminating power (150 liters per hour, slit burner) of 11.8. However, the gas contained 188 grams of sulphur per 100 cu. m. in spite of extended purification and hence was unsuitable for use. It is becoming common practice in Germany to produce lighting[12] gas from wood in combination with coal. The extension of this practice is not the result of a shortage of coal as might be supposed but because it has been found that wood offers certain advantages where the recovery of by-products is carried out to the fullest extent. In the production of gas in Wurtemburg, thirty-five out of sixty-three works are making wood gas. Preference is given

[8] *Gas Jour.*, Oct. 8, 1918, p. 59; also Dec. 3, 1918; pp.503, 510.
[9] *Gas Jour.*, Sept. 17, 1918, p. 537.
[10] *Gas Jour.*, Nov. 5, 1918, p. 292.
[11] *Gas Jour.*, May 20, 1919, p. 439.
[12] *Gas Jour.*, May 20, 1919, p. 427.

to resiniferous kinds of woods in logs of not more than 10 cm. in diameter. The best proportion of wood to coal in the retorts is said to be 1 to 3. The heating value of such gas is given as between 3,000 and 3,500 units.

The great scarcity of coal in Italy[13] has called attention to the discovery of natural gas some years ago near Pisa, and has resulted in investigations and borings which have yielded enough to supply heat and light for the town. This natural gas has a heating value of approximately 9,000 calories per cubic meter, (1,000 B. t. u. per cubic foot), and has been found to be very satisfactory for lighting purposes when gas mantles are employed.

A more or less popular fallacy regarding the danger from explosions and fire in the case of gas works subjected to bombardment by shells from aircraft or warships has been dissipated by a report[14] submitted to the British Institution of Gas Engineers in London. It was shown that despite the sixty-three visits of Zeppelins and airplanes to London and the comparatively thickly scattered gas works, there being no less than eighteen in the inner metropolitan area, only trifling damage was sustained; while in those localities where gas holders were destroyed, the gas contained in them either escaped harmlessly into the air or quietly burned out. In one case 8,000,000 cu. ft. of gas were fired but no damage was done except to the gas holder.

Burners.—Progress in gas lighting seems to have been in the direction of low candlepower units. The most marked development in this country in gas equipment for lighting purposes is a new type of burner and mantle designed to meet the demand for a small and inexpensive unit to replace the old open-flame burner.[15] It consists of a threaded brass base supporting a steel burner tube or chamber with air parts, a mantle cap and gauze and the small globular mantle. The ordinary pillar with its lava tip is unscrewed and the new burner screwed in its place. It is claimed that wide variations in the quality of the gas and in pressure at the burner do not effect its operation; the air and gas adjustments are extremely simple; the burner operates without extinguishing or blackening of the mouth with either lean or rich gas, and under from 1 to 6 in. pressure. The gas orifices are

[13] *Sci. Amer. Sup.*, Aug. 10, 1918, p. 96.
[14] *Am. Gas Eng. Jour.*, June 28, 1919, p. 55.
[15] *Gas Age*, Jan. 1, 1919, p. 64.

adjusted to consume from 1 to 3 cu. ft. per hour giving a luminous intensity of about 25 to 30 candles. Another novel type[16] of burner and fabricated filament has been designed abroad to meet the need of light at a minimum of gas consumption. The burner consumes only ½ of a cubic foot per hour. In front of it and attached by a metal clip is a metal frame enclosing a square of fabric similar to that used in the manufacture of incandescent mantles. The flame impinges on this rendering it incandescent and furnishing, it is claimed, ample light for halls, landings, staircases, bathrooms, etc. The burner is adaptable to any existing gas fitting, but yields the best results when horizontal, a position readily obtained by the use of a small elbow. The mantle frames may be fitted with two mantles, thereby, increasing their candlepower and life. Still another arrangement developed abroad[17] to meet the demand for a lower candlepower light, consists of a miniature Bunsen burner with a special form of mantle resembling a tea-cosey and which is suspended over the burner by means of a wire hook. It is stated that the gas consumed is rather less than 2 cu. ft. per hour and that the light produced has a luminous intensity of about 20 candles.

The waste of coal in this country due to the use of the open-flame[18] burner has been estimated as 2,500,000 tons per year. The agitation for the abolishment of this type of burner continues. The United States Fuel Administration[19] requested all manufactured-gas companies to report the saving in gas if open-flame burners were replaced by gas mantles. Considerable progress has been made in Maryland[20] in the substitution of incandescent mantles for the open-flame burner, a recommendation from the state Fuel Administrator having undoubtedly helped. At Newark, N. J.,[21] a week was set aside by the department of streets and public improvements as "Gas Week" for the purpose of furthering a campaign to abolish flat-flame burners. At Benwood, W. Va.,[22] the city council passed an ordinance making it an offense punishable by fine to burn gas for lighting purposes

[16] *Gas Jour.*, Oct. 29, 1918, p. 231.
[17] *Gas Jour.*, Dec. 31, 1918, p. 710.
[18] *Gas Record*, Sept. 25, 1918, p. 156.
[19] *Gas Record*, Nov. 13, 1918, p. 241.
[20] *Gas Age*, Oct. 1, 1918, p. 291.
[21] *Am. Gas Eng. Jour.*, Nov. 2, 1918, p. 427.
[22] *Ibid*, p. 423.

without a mantle. However, just as in the case of electric incandescent lamps[23] where the carbon filament is still retained in locations where unusual strength is required, so in spite of its inefficiency, the open-flame burner is, and may still be used for such places as closets, cellars, hall-ways, garrets, and for locations where the burner is used for a moment, or where there is a strong draft. In such places the renewal cost of mantles is apt to be high.

Characteristics.—The British Institution of Gas[24] Engineers has published the report of a research committee which contains, among other things, the first part of a study of the effect of gas composition on mantle burners. The initial report deals with upright burners only, on the efficiency of which flame size and flame shape have an important bearing, and the results should not be applied to inverted mantles, tests on which were subsequently reported. It is pointed out in the initial report that since for satisfactory lighting, the mantle must be placed exactly in the zone of combustion, and since in an upright burner the mantle is fixed, the zone of active combustion must be made to fit the mantle. This requirement is so stringent that with all gases which could be proposed as reasonably suitable for public supply, other considerations, such as that of flame temperature become relatively unimportant. The position and character of the zone are changed by changing the consumption, or the degree of aeration. With gases of about 450 B. t. u. gross and below, the control that it was possible to obtain by varying the consumption and aeration was not, the investigators found, sufficient to give satisfactory illumination. Gases of low heating value and high inerts were found to be distinctly inferior on all grounds to gases of similarly low calorific value but low inerts, that is, consisting mainly of low grade combustible material. When a reduction in illuminating power and efficiency accompanies a reduction in calorific value or an increase in inert constituents, the result is due directly to unsatisfactory size and shape of the flame and its position with respect to the mantle. A typical upright burner of good modern make was used and as long as possible the same mantle. Eight different qualities of gas were employed and in each case the

[23] *Gas Record*, Feb. 26, 1919, p. 129.
[24] *Gas Jour.*, Oct. 22, 1918, p. 17[illegible]; Oct. 29, 1918, pp. 241, 24[illegible]; Nov. 5, 1918, p. 2[illegible].

number of British thermal units supplied to the burner per hour was varied within wide limits. A new basis of reckoning[25] the performance of burners was introduced by the committee, who proposed stating results in British thermal units per candle-hour. The report aroused quite a discussion. Further information[26] on upright burners was given in the next report of the committee made in May this year. The results indicated the important part played by the chimney, a typical test showing 69 candlepower with the chimney and 48 candlepower without. The results also confirmed previous conclusions that under suitable conditions gas of low-heating value is capable of yielding very high candlepower. Attention is called to the fact that nipple orifices must be modified to enable the delivery of the necessary British thermal units without excessive pressure. Confirmation of this point is to be found in a report of experiments[27] in Germany which showed that the width of the magnesium orifice of a burner has a marked effect in the case of inverted-mantle lamps.

An elaborate study has been made[28] of the radiation characteristics of the Welsbach mantle. The mantle of commerce is treated as one of a group of possible combinations of radiating materials behaving according to the same general laws, but remarkable among them for the degree to which the characteristics of selective radiation are exhibited. Special attention was given to the behavior under various conditions of the absorption bands to which the enhanced visible radiation of the more efficient mantles is due. As a result of an investigation of the energy relations existing with the flame heating of different materials, it has been found possible to fix the limiting efficiency of gas lighting production by present methods. Data on the various mixtures of colored oxides with thoria indicate that their behavior is the same, differing, however, greatly in degree. In all cases an optimum mixing proportion was found. The value of the luminous efficiency at the optimum is greater for ceria, below which come uranium oxide and neodymium oxide. The comparatively high efficiency of both the cerium

[25] *Ill. Eng.* Lond.), Sept., 1918, p. 215.

[26] *Gas Jour.*, June 3, 1919, pp. 565, 607.

[27] *Gas Jour.*, June 3, 1919, p. 637.

[28] *Sci. Abs.*, (A), Jan. 31, 1919, p. 24; *Jour. of Frank. Inst.*, Oct., 1918, p. 401.

and uranium oxides is due to the presence of a strong absorption band in the blue end of the spectrum. One of the most interesting facts brought out by these data is that the color characteristics of mixtures are not always additive. This is exemplified by the neodymium oxides. The results on temperature measurements show that the efficiency of radiation increases by about three times as the temperature rises from 1,900° K. (the regular mantle temperature) to 2,100° K. Evidence is given that ceria begins to volatilize at the ordinary operating temperature of the mantle.

Oil.—A lantern which burns gasoline for fuel[29] employs a mantle of the inverted type. A pressure of from 10 to 30 lbs. is established in the containing tank by means of a common bicycle pump and the lantern is started by heating with an alcohol torch a tube through which the gasoline passes after which the tube is kept hot by means of a special arrangement. With a pressure of 16 lbs. it is claimed that this lantern will develop 147 candlepower and will burn 23 hrs. on 1 gal. of fuel. For lighting camps, hospital tents,[30] etc., a portable oil lamp has been devised which uses special incandescent mantles of an exceptionally strong character and which are claimed to have an average useful life of about 500 hrs. The lamps may be hung from a ceiling or from a tripod capable of raising them 9 ft. from the ground, and may be moved about while lighted. Since June 30, 1917, twenty-seven new[31] acetylene lights have been placed in Alaska by the Bureau of Lighthouses.

Accessories.—A tentative set of specifications covering the requirements in a satisfactory flexible tubing for gas was drafted[32] by committees of the American Gas Institute and the National Commercial Gas Association in 1916. At about the same time tests on tubing were begun at the Bureau of Standards and while the work was interrupted during the war, a preliminary report has been published. Experiments were there made on the transverse strength; tensile strength; tightness when straight, bent or twisted; pressure loss; heating; freezing; rubber tip and detachable metal end pieces. The specifications have been submitted for

[29] *Sci. Amer.*, Mar. 8, 1919, p. 232.
[30] *El. Eng.* (Lond.), Aug., 1918, p. 204.
[31] *Jour. Acet. Ltg.*, Oct., 1918, p. 87.
[32] *Gas Rec.*, June 25, 1919, p. 393.

criticisms and comments. An ordinance[33] covering such specifications for the purpose of regulating the sale of flexible gas tubing was presented to the Board of Aldermen of New York City by the Commissioner of Health. Power to inspect, condemn and seize will be invested in the Commissioner of Water Supply, Gas and Electricity.

Analyses of monazite[34] sands of Lower Burma by the Geological Survey of India show amounts of thoria too small to be of practical utility.

Standardization.—In 1917, the British Board of Trade requested the Fuel Research Board[35] to advise "as to what is the most suitable composition and quality of gas and the minimum pressure at which it should be generally supplied, having regard to the desirability of economy in the use of coal, the adequate recovery of by-products, and the purposes for which gas is now used." The Fuel Research Board having made the necessary investigations and inquiries has made a report, and among others has come to the following conclusions: "It seems desirable that the representatives of consumers, producers, and the makers of fittings and burners should jointly decide on the standardization of burners and appliances for a limited number of calorific values. It is suggested that four standards may be sufficient,—400, 433, 466, and 500. If these are regarded as minimum figures, the adjustment in each case should admit of increased aeration to suit gases up to the next higher standard." It is further proposed that the gas company declare the calorific value of the gas it intends to deliver and undertake to adjust the consumer's fittings in accordance therewith. The above proposal for four standard calorific values is analogous to the voltage standardization now going forward in the electrical industry.

Calorific Standards.—The Bureau of Standards is getting out a revised edition[36] of circular No. 32 on Gas Service. In connection with the question of heating values the Bureau has determined not to adopt the suggestion that candlepower be made a specification. They do not recommend that candlepower standards be abandoned, but point out the apparent inadequacy of

[33] *Am. Gas Eng. Jour.*, Nov. 16, 1918, p. 467; *Gas Jour.*, Apr. 29, 1919, p. 569.

[34] *Jour. of Indus. & Eng. Chem.*, Dec. 1918, p. 1020.

[35] *Gas Age*, June 2, 1919, p. 569.

[36] *Gas Age*, July 1, 1919, p. 24.

candlepower as a unit of modern consumption. While not attempting to define the number of British thermal units to be used as a standard in any locality, the Bureau seeks to point out a basis on which the British thermal unit standard should be applied.

The Indiana State Commission authorized[37] a survey of all gas plants in the state for the purpose of securing information on the advisability of adopting for a calorific standard, either the 528 B. t. u. or some standard other than the 600 then in use. After this survey was completed,[38] a series of tests were started to determine just the quality of gas it is possible to maintain at four of the coal-gas plants of the state. It is said that this is the first thorough investigation of its kind to be conducted in any state. At the close of their investigation, the committee established[39] 570 B. t. u. as the minimum monthly standard for the state with a daily minimum of 540 B. t. u. According to this standard the gas company will be required to keep within limits of 60 B. t. u. Nine other states have been watching the investigation and will abide by the result of the work. At the the end of a long controversy[40] waged before the United States Fuel Administration it was decided not to recommend the adoption by the government of a 528 B. t. u. standard for gas. The question is to be left to the Public Service Commission of each state. The New York[41] Commission has already filed a report against the adoption of this standard, and in general the proposal to establish this value for a standard[42] has met with opposition. The Canadian Gas Association at their 11th annual meeting[43] decided to advocate to the government a lowering of the Canadian standard to 460 or 480 B. t. u. The Gas Works[44] Order for 1918 of the British Ministry of Munitions called for a minimum requirement of 450 B. t. u. for gas supplied to consumers. War conditions compelled the Italian[45] gas engineers to economize to such an extent that gas produced dropped from 560 B. t. u. to about 225.

[37] *Gas Age*, Dec. 2, 1918, p. 485.
[38] *Am. Gas Eng. Jour.*, Mar. 8, 1919, p. 224.
[39] *Am. Gas Eng. Jour.*, June 14, 1918, p. 522.
[40] *Gas Age*, Oct. 15, 1918, p. 356.
[41] *Ibid.*, p. 358.
[42] *Gas Rec.*, Sept. 25, 1918, p. 148.
[43] *Gas Age*, Sept. 2, 1918, p. 218.
[44] *Gas Age*, Sept. 16, 1918, p. 275.
[45] *Gas Jour.*, July 30, 1918, p. 202.

ELECTRIC INCANDESCENT LAMPS.

The development of the tungsten-filament electric incandescent lamp has been so relatively rapid and such marked improvements in the regular product were made just a few years ago, that the changes in the past two years seem of minor importance. They have been confined more to special lamps, such as those for moving-picture work and for locations requiring a very rugged construction. This may be partly explained by war conditions, when labor shortage and the difficulties of obtaining supplies required a concentration of effort to meet the steady demand for the regular output.

The term "half-watt" originally unfortunately applied to the modern gas-filled tungsten filament lamps, has been quite effectually disposed of in this country, but apparently, in England it has been found difficult to eradicate and, in spite of frequent explanations of why it is a misnomer, the term is still used in the technical press.[46]

Manufacture.—The demand for tungsten has become so vast that a shortage threatened toward the close of last year.[47] It was reported that Great Britain, France and the United States were negotiating for the world's supply, Great Britain to take all from Burmah, the United States all produced within her borders, and the production from other sources, to be divided between the three countries named. A new material for filaments has been patented.[48] It is an alloy comprising zirconium and iron. Among the claims made for this alloy are little if any tendency to oxidize, high resistance to most chemical reagents, and the property of selective radiation in a direction to produce more light for the same wattage than that given by ordinary lamps.

The tungsten filament lamp is showing a gain in use over last year,[49] while the carbon filament lamp shows a decrease. The manufacture of gem lamps was stopped at the beginning of the year and now no gem lamps are available. Owing to the increased use of automobiles and flashlights, the miniature tungsten lamps have shown considerable growth. They are also being used in increasing number for candelabra and Christmas-tree lighting.

[46] *Elec. Rev.* (Lond.), Jan. 10, 1919, p. 45.
[47] *Elec.*, Oct. 4, 1918, p. 468.
[48] *Elec. Rec.*, Dec., 1918, p. 44.
[49] *Report of Lamp Com. N. E. L. A.*, May 19, 1919.

From the standpoint of popularity, the demand for tungsten filament lamps shows the 40-watt size to be the most popular with the 25-watt a close second, followed by the 50 and 60-watt sizes. The average candlepower of lamps of all types has shown an increase of 4 per cent., the average lumens per watt being over three times that of the year 1907 when tungsten filament lamps were first introduced. Two lamps have been standardized for moving-picture work, one, a 600-watt, 20-ampere, 30-volt, recommended only where the throw is short, the screen small or the power supply limited; the other one generally recommended, being the 900-watt, 30 ampere, 30-volt.[50]

The universal effort to conserve fuel found[51] an opportunity for manifestation in the incandescent lamp industry and resulted in a recommendation on August 29, 1918, to take effect September 15, 1918, that the manufacture and use of carbon filament lamps be discontinued in all but a few isolated cases. This was the result of a conference of the manufacturers of lamps and the Fuel Administration on July 15th, at which time a committee was appointed to work out the practical means of eliminating from production various unnecessary lamps, limiting the output of carbon and gem lamps, and in general, discouraging the use of larger sizes where smaller ones would give adequate illumination. The effect began to be evident in the monthly statement of the Bureau[52] of Foreign and Domestic Commerce for the month of October which showed an increase in the use of tungsten filament lamps at the expense of carbon filament lamps. It is interesting that during that month over 100,000 carbon filament lamps were imported from Japan. However, all restrictions and limitations placed on the production and distribution of inefficient lamps and voluntarily assumed by manufacturers, central stations, jobbers, etc., were removed on January first,[53] the urgent need for conservation having passed.

A report of conditions in France[54] just before the close of the war stated the capacity of French electric incandescent lamp factories as fifteen to twenty millions of lamps per year, but that

50 *Gen. Elec. Rev.*, July, 1919, p. 556.
51 *Elec. Wld.*, Sept. 7, 1918, p. 457, also *Elec. Rev.* (U. S.), Sept. 7, 1918, p. 371.
52 *Elec. Rev.* (U. S.), Dec. 28, 1918, p. 1009.
53 *Elec. Rev.* (U. S.), Jan. 4, 1919, p. 32.
54 *Elec. Rev.* (Lond.), Oct. 25, 1918, p. 406.

this figure might be doubled in the near future. Argon gas is being made in considerable quantities by the Claude process. It is also reported[55] that the manufacture of incandescent lamps has been started with satisfactory results in Santiago, Chile. Prior to the war[56] most of the electric incandescent lamps used in Norway were made in Germany, but in the past two years they have been manufactured locally, and the early output of 4,600 lamps per day has recently been augmented. A state monopoly[57] of the supply and sale, either together or separately of a number of materials including electric lamps has been proposed in Italy by the Minister of Finance, the Minister for the Treasury and other Ministers concerned.

Types.—The latest development in the electric incandescent[58] lamp is a 50-watt, gas-filled type having a white glass, tipless bulb which so completely diffuses the light that the filament is practically invisible. This lamp is now ready for distribution. To meet the demand for a rugged type of tungsten filament lamp[59] which would stand more shocks and vibrations than the regular product, a new lamp, known as the "mill-type" has been developed, which has its filament in a vacuum and the filament mounting is flexibly attached to the base by a piece of steel wire in order to absorb vibrations. Each alternate filament ieg is attached to an additional anchor in order to prevent overlapping. While still considered in the experimental state these lamps are available in two wattages, 25 and 50, in both the 110-125 and 220-250 volt ranges. They are not quite as efficient as the ordinary tungsten-filament vacuum lamp, but much more so than the inefficient carbon-filament type, formerly employed because of their ability to stand rough usage. Improvements have been made[60] in the small lamp in the form of an annulus devised for illumination in microscopic work. The new lamp is a 9 volt, 0.7 ampere unit of blue glass to imitate daylight color. A rheostat has been added to the equipment and connection is made to an ordinary socket, the rheostat being tapped for three voltages. Tests with a 1

[55] *Elec. Rev.* (Lond.), Nov. 8, 1918, p. 444.
[56] *Elec. Times*, Feb. 6, 1919, p. 84.
[57] *Elec. Times*, Dec. 26, 1918, p. 389.
[58] *Elec. Wld.*, May 31, 1919, p. 1194.
[59] *Bul. N. E. L. A.*, Dec., 1918, p. 595.
[60] *Jour. of Ind. and Eng. Chem.*, Dec., 1918, p. 1013.

ampere, 13 volt clear glass lamp of the above type clamped to various objectives and allowed to run continuously for a half hour showed no injurious effect on the lenses. Experiments have also been made on a type with silvered instead of enamelled reflecting surfaces. It is claimed that with lamps of this type, intensities much greater than any hitherto available have been obtained.

Properties.—As a result of keeping careful records[61] on lamp installation and maintenance for four years in a park system comprising 1,561 gas-filled tungsten filament, 400 candlepower 15 ampere lamps, and 300 special multiple large-sized units for outside lighting, as well as approximately 6,500 internal lights, some interesting facts have been deduced. For instance, in analyzing the life records it was found that in a preponderant number of cases, lamps, installed on the same date on circuits operating all night, half the night, and alternating, will have a life that depends to a larger extent on the number of times the lamp in question is cut in and cut out, than on the number of hours of actual operation. The characteristics of electric incandescent lamps where the filament functions in a vacuum[62] have been studied at some length in the past. It was natural that these characteristics should be determined for lamps where the bulb contains a gas. Data have been published on gas-filled tungsten filament lamps operating on both direct and alternating current. Six lamps were tested, two each of 25, 32 and 50 candlepower, the filament being in the shape of a polygon with its plane perpendicular to the axis of the lamp. The self-induction was found to be practically negligible. The ratio of hot to cold resistance, using direct current was found to be approximately 15. The coefficient of change of candlepower with change of voltage at normal operation varied from 2.4 for the 25 and 50 candlepower lamps to 3.4 for the 32 candlepower lamps on direct current and lower values on alternating current. The candlepower during life test was found to increase at the beginning and then to decrease, the resistance decreasing and then increasing in an exactly correlative manner.

Standardization.—As an illustration of the extent to which the study of details is being carried on in the manufacture of electric

[61] *Elec. Wld.*, June 7, 1919, p. 1215.
[62] *Rev. Gen. d'Elec.*, May 10, 1919, p. 683.

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incandescent lamps, reference should be made to the report of a French commission[63] which has made an elaborate investigation for the purpose of standardizing the screw bases and sockets. Uniform dimensions and an international system of nomenclature for the various parts have been recommended. In England,[64] the proposal to standardize 100, 110, and 115 for low, and 200, 220 and 230 for high voltages has been formally endorsed by the Tungsten Lamp Association. It was felt, however, that the change should be made gradually and a wider range was adopted initially.

The demand for the elimination of special goods aroused by war conditions has stimulated the desire on the part of the lamp manufacturers to learn what lamps are standard and what are non-essential.[65] Many sizes of tungsten filament lamps formerly supplied as a regular product have been made subject to special orders. The effort to standardize the voltage of central stations[66] referred to in this report in 1916, is meeting with some success as is evidenced by data collected last fall which showed an increase of 12 per cent., in the number of stations operating on one of the three voltages standardized, that is, 110, 115 and 120.

ARC LAMPS.

No striking developments have been reported in those types of arc lamps used for illumination. Developments in arcs for moving-picture work and in searchlights will be found under the caption, "Lamps for Projection Purposes."

Vapor Lamps.—A new arc lamp[67] consists of an envelope of low-expansion material, such as sodium-magnesium or boro-silicate glass, with a cathode of tungsten, tantalum or carbon. The anode is made of metallic calcium, magnesium or other metal highly reactive to gases other than the inert, so-called rare or monotomic gases. The cathode is preferably provided with a tip having a greater diameter than adjoining sections. The voltage required to start the lamp is low and the drop across the arc may

[63] *Rev. Gen. d'Elec.*, July 6, 1918, p. 9.
[64] *Elec.*, Aug. 30, 1918, p. 369.
[65] *Elec. Wld.*, Feb. 8, 1919, p. 290.
[66] *Elec. Wld.*, Nov. 30, 1918, p. 1052.
N. E. L. A. Bul., Sept., 1918, p. 469.
[67] *Wireless Age*, Mar., 1918, p. 453.

be as low as 4 or 5 volts. A 15 ampere arc may be formed with a potential as low as 14 volts, provided the temperature of the cathode is 2,500° C. A new quartz mercury lamp[68] has been described. The bulb is annular in shape and the two cavities holding the mercury electrodes are in contact so that there can be an exchange of heat. Water cooling is provided and, it is claimed, the current may be varied from 2 to 10 amperes and the voltage from 25 to 150 volts. The luminous intensity has been reported to reach 5,000 candles with a specific consumption of 0.2 watt per candle. Tests have been made[69] on the carbon-dioxide Moore Tube, U-shaped, 3 m. long and 40 mm. in diameter. It was shown that the specific consumption in watts per hefner candle reached a minimum with increasing current, beyond which a further increase resulted in an increase in watts per hefner, as shown by the following table:

Watts consumed	Watts per hefner candle
900	6
2,100	4.7
2,900	4.9
3,600	5.1

Replacing the carbon dioxide with nitrogen the watts per hefner changed to between 1 and 2. Experiments with a Moore Tube containing neon[70] and a little helium showed a specific consumption of only 0.26 watt per Hefner compared with 0.45 watt per Hefner for a similar tube containing argon. The potential drop in the neon tube was 30 volts at the electrodes, 110 volts over the neon arc or luminous column, and 80 volts in a series resistance. The relation between current, i, and voltage e, satisfied the equation:

$$e = 114 + \frac{26}{i}$$

for a tube 21 mm. inside diameter containing 1 mm. of neon and a little helium. The watts per hefner reached a minimum at about 0.29. Experiments with different compounds for electrodes showed a cathode composed of cadmium and thalium to be the most efficient. As used commercially, the tube is filled with gas, (75 per cent. neon, 25 per cent. helium) at 1 mm. pressure. Neon is not occluded and, it is claimed, lamps will burn more than

[68] *Elek. Zeit.*, Mar. 28, 1918, p. 129.
[69] *Bul. Assoc. Suisse des Electriciens*, June, 1918, p. 129.
[70] *Chem. Abs.*, Feb. 20, 1919, p. 285.

2,000 hrs. Owing to its penetrating red rays, the use of this lamp in signalling has been suggested. Another neon lamp,[71] designed for 220 volts with a consumption of from one to five watts has a small glass bulb about 1 or 2 cm. in diameter filled with neon plus a little helium at 7.6 mm. pressure. The electrodes are iron spaced 5 mm. apart. The luminous intensity is dependent on the area of the cathode surface and the pressure of the gas. The voltage increases slowly with the current. No high-tension starting voltage is necessary, as the lamp begins to glow instantly on a 220-volt circuit. The voltage drop between terminals is nearly equal to the drop at the cathode. A small resistance is connected in series with the lamp and determines the maximum current. About 90 per cent. of the emitted neon light falls within the wave-length range of 0.65μ to 0.570μ and the orange color is partially corrected by mercury vapor, producing a pinkish-white effect. A 210-volt lamp is said to have 0.44 hefner candlepower at 19.2 milliamperes, taking 4.03 watts from the line and hence operating at 9.2 watts per hefner.

Characteristics.—The increased use of the quartz mercury lamp as a source of ultra-violet radiation for commercial purposes has emphasized[72] the importance of knowing its physical characteristics and the effect on them of continued burning throughout the life of the lamp. It is known that the intensity of radiation, especially the ultra-violet component decreases greatly with usage. In connection with an investigation of this point, data were obtained on the variation of emissivity with power input. The curve of the data on one lamp is well represented by the equation: $E = 0.00462\ W^{1.83}$, where E is the total radiation of energy less than 1.4μ and W the watts input. During a 1,000-hour burning, the ultra-violet radiation (λ less than 0.45μ) was reduced from 70 per cent., of the total radiation less than 1.4μ, when the lamp is new, to 50 per cent. The total radiation decreased in intensity by one-half to one-third the initial value. Compared to solar radiation, it was found that the quartz mercury lamp gave about the same ultra-violet radiation (less than 0.45μ) when the radiation from 0 to 1.4μ was one-tenth that of the sun. A new determination of the electric force[73] in the mercury arc has given values which increase as the density of the

[71] *Ibid*, p. 286. (From *Elek. Zeit.*, Apr. 24, 1919.)

[72] *Bul. Bur. of Stds.*, 15, Nov. 12, 1918, p. 1.

vapor increases, forming approximately a linear function. When the current was increased from 3 to 7 amperes, the electric force decreased about 8 per cent. Values of temperature were obtained higher than those usually ascribed to the arc and ranged from 925° K. at a pressure of 0.47 mm. to 1,080° at 4.12 mm.

LAMPS FOR PROJECTION PURPOSES.

Signal Lamps.—The change from semaphores to the use of electric lamps arranged when lighted to show the semaphore positions, which was made on one of the large railroads of this country[74] in 1915 has been made on an English railway. In order to avoid possibility of failure to operate in the case of block signals, a suburban company[75] has installed a type containing two circuits, each consisting of four electric incandescent lamps and one resistance coil. The lamps as well as the coil are provided with automatic shunts and the failure of any lamp or coil is at once indicated by a compensating lamp, while one good lamp remains behind the colored lens. The compensating lamps are in a separate compartment and are visible through a long narrow strip of frosted glass.

A small flashlight of interest to military men and others, consists[76] of a shallow metal case containing the batteries, on top of which is the lens, the whole being strapped to the back of the hand by a fingerless glove. A switch button on the palm-side of the glove is easily operated by one finger, either to flash signals or to light the way. Experiments have been made[77] to see whether the incandescent lamps used for signalling purposes by making and breaking the current through them, will operate as, or more rapidly than the eye can detect the signals. A preliminary investigation showed that with the Morse system, the average proportionate lengths of time for the dot, space and dash should be as 1:4:3. It was found that the maximum speed of reading the signals was about the same for all observers, whether the signals were formed by moving a sector in front of the lamp or whether they were formed by making and breaking the current, thus indicating that the lamp functions at least as fast as the signals can be read.

[73] *Phys. Rev.*, Oct., 1918, p. 277.
[74] *Ill. Eng.*, (Lond.), Oct., 1918, p. 238; also *Progress Report* TRANS. I. E. S., Oct., 1915, p. 526.
[75] *Elec. Ry. Jour.*, Nov. 30, 1918, p. 977.
[76] *Pop. Mech.*, Nov., 1918, p. 716.
[77] *Phys. Rev.*, Feb., 1919, p. 149.

Searchlights.—A new searchlight[78] of the high-power class is a modification of the Beck and Sperry types, in which the positive carbon is cooled by an air-jet. An important auxiliary result is the reduction of the arc pressure to 50 volts instead of the 70 volts of the Beck and Sperry lamps. Three motors are used, one for slowly rotating the positive carbon, another for the centrifugal pump producing the air-jet, while another energizes the apparatus for extracting the smoke produced by the combustion of the carbon. As actually constructed, the apparatus absorbs 120 amperes. Special care is required in choosing the carbons. The copper sheath must not be thicker than 0.06 mm. as otherwise, the drops of molten copper damage the mirror. The core of the positive carbon must not have too low a melting point and must be formed chiefly of cerium salts. During the war, four main sizes of projector for searchlights for coast defense and anti-aircraft purposes were standardized,[79] *i. e.*, 60, 90, 120, and 180 cm. For mobile anti-aircraft work in France the largest size in use was the 120 cm. projector. While there were some modifications in both lamp and projector, the principle field for experiments during the last four years has been in the direction of finding a suitable system of control, the choice lying between distant control of three types, and simple hand control from behind the projector. The latter was largely abandoned. That standardized for mobile and anti-aircraft work was the "bar" control from a distance of 12 feet, (5.7 meters). Electrical control, while apparently the best, could not be adapted to mobile work during the period available for its perfection. The War Department in reviewing the work of the Army Engineer Corps in the war, stated[80] that a new form of searchlight was produced which weighed one-eighth as much as lamps of former design, cost only one-third as much, was about one-fourth as large in bulk and threw a light 10 per cent. stronger than any other portable projector in existence.

Locomotive Headlights.—The majority of railroad[81] companies have already equipped their locomotives with high-powered headlights, although a year still remains before the ex-

[78] *Electrotecnia*, July 25, 1918, p. 286.
[79] *Elec. Rev.* (U. S.), Feb. 28, 1919, p. 277.
[80] *Elec. Wld.*, June 7, 1919, p. 1236.
[81] *Ry. Elec. Eng.*, June, 1919, p. 186.

piration of the time limit set by the Interstate Commission. Electric headlights have been introduced[82] on switch locomotives. One railroad uses turbo-dynamos made to generate three chief pressures, 24, 36, and 47 volts and this enables the use of lamps for headlights giving respectively 200 candlepower, 240 candlepower and 280 candlepower.

At the last convention of the Association of Railway Electrical Engineers, the committee on electric headlights presented[83] for consideration a number of proposals covering maintenance, operation and application of electric headlights for locomotives. Among other suggestions were the following: a 32-volt system; use of auxiliary resistance in series with the lamp to permit initial heating of the filament before throwing on full voltage; standardizing of a special headlight lamp for switching and yard service; standardization of location of headlight cases for the various types of engines; metal polish should not be used for cleaning reflectors, but a combination of lamp-black and signal oil is recommended; for locomotives in road service and helping service, lamps of 250-watt size; in yard service, 100-watt; for cab and classification work for locomotives in all types of service 15-watt. The experience of one of the large railroads in converting direct current generators formerly used for supplying arc-lamp headlights[84] so as to give alternating current at lower voltage for incandescent-lamp headlights as well as direct current for cablights has been found to be very satisfactory. This arrangement permits of the use of 6-volt, 108-watt lamps which are said to be more rugged and less effected by excessive voltage than the ordinary lamp used for the purpose.

Automobile Headlights.—By silvering the tip of the lamp bulb[85] and using an outside reflector projecting beyond the ordinary parabolic form, two beams of light are obtained from an auto headlight. The parabolic reflector gives the main beam which illuminates the road at a distance. Light reflected from the extended part to the bulb is re-directed into a broad beam

[82] *Elec.*, Oct. 4, 1918, p. 408.
[83] *Ry. Elec. Eng.*, Oct., 1918, p. 295.
[84] *Ry. Elec. Eng.*, Nov., 1918, p. 365.
[85] *Elec. Rec.*, May, 1919, p. 311.

which gives a general illumination in front of the car. A very novel method[86] of automobile lighting involves the conventional number of headlights, side, dash, and tail lights but employs only one high-candlepower incandescent electric lamp. The light from this lamp is distributed to the various needed positions by means of a system of lenses and mirrors. A control lever on the dashboard enables various adjustments to be made by the driver. All exposed wiring is eliminated. A mathematical[87] study of the beam of light thrown from a headlight of the automobile type has lead to the conclusion that the beam from a linear type of filament will be better from a standpoint of horizontal spread than that from a lamp having a V-shaped filament. It is suggested that the effect of the shape of the filament is a phase of the headlight question which has not been adequately considered.

Motion-Picture Projection.—A new arc lamp,[88] which in small sizes, is said to have found considerable favor in motion-picture projection has a water-cooled copper ring for the negative pole. This ring is placed concentrically around the end of the positive carbon. The arc is struck by an automatic adjustment between the carbon and the ring and does not concentrate at one point in the ring, but travels around it producing a central small crater in the positive carbon and at the same time distributing the heat over the circumference of the cooling ring. The latter does not obstruct in any way the beam of light from the crater and any ordinary methods of projection may be used. In a lamp of standard size with a voltage of 55 and a current of 43 amperes, a positive crater 17.6 sq. mm. was formed with a brightness of 700 candles per square millimeter. The cooling of the annular ring is produced automatically through convection currents of quite a small quantity of water. The feed of the carbon is automatic and the feeding mechanism is controlled by means of a thermo-couple. The over-all weight is about 45 lbs. (20 kilos). For work in taking motion pictures outside the regular studio,[89] a portable arc lamp has been devised, which has twin carbons, cored with a magnesium compound, and the unit is said to produce from 8,000 to 15,000 candlepower, depending upon how the carbons are con-

[86] *Elec. Rev.* (U. S.), July 26, 1919, p. 170.
[87] *Jour. of the Optical Soc. of Amer.*, Sept.-Nov., 1917, p. 155.
[88] *Elec. Rev.* (Lond.), Dec. 27, 1918, p. 625.
[89] *Illus. Wld.*, May, 1919, p. 344.

nected up. To avoid harsh shadows, the light is filtered through a spun-glass screen and the whole apparatus can be concentrated into a package easily carried by one hand. It is claimed that three of these lamps will illuminate a stage 30 ft. by 50 ft. A self-contained twin arc lamp[90] for use by photographers and moving-picture studios is fitted with a triangular shadow-breaking device which softens the double shadows usually prominent when twin-arcs are used without diffusers. The lamp has two doors which act as reflectors and any desired angle of light reflection may be obtained by adjustment of these doors.

The relation between current, candlepower and carbon size in a direct current arc as used in moving-picture projection machines has been investigated.[91] Among the conclusions reached were that candlepower is directly proportional to the current within the limits of operating range; within this range the candlepower decreases with increasing size of carbon at a given current. The maximum efficiency is obtained when a carbon is burned just below the pencilling point; crater area is directly proportional to the current for a given size carbon and increases with the size of the carbon at the same current. The increase in light with increased current has been shown by another investigator to continue even after the crater area exceeds the capacity of the lens system. Definite reasons have been put forth in explanation, but they are too involved to include in this report.

Miner's Lamps.—Approval of a new miner's lamp, together with amendments to the specifications of some previously approved lamps were ordered[92] by the British Home Office over a year ago. The lamp referred to has a battery case of spun or drawn sheet steel with a cover fitted with a magnetic lock. The bulb holder is an ebonite base plate through which electric connection is made to contact plates on the under side. The total weight of the lamp is not more than 6 lbs. and it gives not less than one candlepower, in a horizontal plane, for 9 hours. A miner's acetylene lamp[93] described before the British Institute of Mining Engineers may be used to detect the presence of fire-damp as well as to indicate lack of oxygen. The upper

[90] *Elec. Rec.*, Jan., 1919, p. 17.
[91] *Moving Picture World*, Mar. 15, 1919, p. 1495; also May 24, 1919, p. [illegible]
[92] *Elec.*, Aug. 9, 1918, p. 325; also Sept. 13, 1918, p. [illegible]
[93] *Sci. Amer. Supp.*, Jan. 4, 1919, p. 14.

part follows the construction of an American type having a corrugated shield, double gauze and special chimney, having the usual horizontal gauze and protecting disk at the upper end of the cone. But there is a double glass which practically makes two safety lamps in one, and if the outer glass is broken, the flame is still protected and cannot cause ignition of gas in the outer air. In the generator which is placed in the base, the contact system is employed. To meet the difficulty of extinction by inattention or concussion due to shock-firing, an automatic re-igniting burner is supplied, so constructed that a temperature sufficient to ignite the gas is maintained in the burner itself. It is claimed that the lamp has about five times the illuminating value of the average oil lamp and about three and one-half that of an electric miner's lamp. It is provided with a special reflector which furnishes sufficient illumination of the roof without tilting the lamp. Another new miner's lamp recently placed on the market in this country has a number of unique features.[94]

It comprises a two-bulb reflector lamp fitting the lamp bracket of the customary miner's cap, and the whole outfit including the storage battery for belt carriage weighs slightly over 12 lbs. A hemispherical reflector spreads the light rays over a 7 ft. (2.1 m.) circle at a distance of 20 ft. (6 m.). Both bulbs are not used at the same time, but in the case of a burn-out or a breakage of one, a special switch enables the use of the other. In case of breakage, two springs which clamp the base of each bulb into position flip the bulb or its remains out of place and thus break the electrical contact. The flux from the lamp is 22 lumens, and when a 4-volt, 5-ampere lamp is used, the lamp and battery rating is 12 hours.

The British Home Secretary has appointed[95] a commission to inquire into and report on possible improvements in miner's lamps as regards safety and illumination, and alterations which may be desirable in the present methods of testing and appraising such lamps. Investigations carried on in Spain[96] to find a suitable substitute for petroleum as a fuel for miner's lamps resulted in a mixture containing 77.5 per cent. of 96° alcohol and 22.5 per cent. benzol. An objection to this mixture lies in the

[94] *Elec. Wld.*, Dec. 28, 1918, p. 1252.
[95] *Elec.*, May 16, 1919, p. 580.
[96] *Pop. Mech.*, Feb., 1919, p. 200.

fact that the illuminating power of a lamp burning it is only 77 per cent. of that when a lamp burns petroleum. Nevertheless, this combination has found a degree of favor with the miners. Another mixture has been tried consisting of 62 per cent. by volume of 96° alcohol, 16 per cent. of benzol, 7.5 per cent. of rectified turpentine and 14.5 per cent. of fusel oil.

The Bureau of Standards has issued[97] a circular on dry cells, such as those used for flashlight purposes, describing the theory, sizes and kinds, electrical characteristics and methods of testing. There is also included a set of specifications which may be used in purchasing such cells in quantity.

INFLUENCE OF THE WAR.

As has been said by one writer, "It[98] may be confidently believed that the world war has been of material benefit to the American people by the checks placed upon lighting waste and extravagance........" In perhaps no other way could the losses due to poor lighting and the benefits accruing from better factory illumination be brought so forcibly to the attention of both the manager and the employee. The effect of diminished street and shop lighting has emphasized how much of the former was due to the latter, and the importance of good street lighting to both the shop keeper and the pedestrian who is a potential buyer. No one who has not lived under those conditions can appreciate what it must mean to those abroad to be free from the fear of air-raids and to have normal lighting restored to all out-door localities. How many of the special lighting devices which were developed solely as a result of the requirements of war times will find practical application in peace times, it is hard to say, but the experiences gained in such directions as signalling, for instance, will surely have commercial value.

Apparatus.—What was called[99] a "trench truncheon torch" was invented to take the place of a weapon, if need be, for the man provided with it. It was said to give 30 hours continuous light and to be usable as a flashlight for 3 months. By a special system of filling, fifty could be put in a rack at one time

[97] *Cir. No. 79, Bur. of Stds.*, Apr. 25, 1919.

[98] *Elec. Rev.*, Dec., 1918, p. 21.

[99] *Elec. Rev.* (Lond.), July 26, 1918, p. 87.

and changed in 1 hour. For night bombing,[100] an airplane flare was perfected for use by the army in France. The flare, released by a lever, has its fused mechanism operated by the air resistance. The amount of light given is said to be equivalent to that of a battery of from 150 to 175 street arc lamps. A huge parachute holds the flare suspended in the air for a length of time sufficient to enable the aviator to select his objective or target and drop his bombs. One of the bizarre[101] methods developed during the war was the employment of invisible radiation in signal work. The combination of a special 6-volt electric lamp with a lens and telescope gave a beam narrow enough to insure secrecy and still cover the observation post, but where it was desirable to show no light whatever, filters were employed to cut out the visible spectrum, a deep red for day-time work and an ultra-violet at night. The observing post was provided with a similar red screen for use at night. The range in both cases was about 6 miles. For naval convoy work, invisible lamps radiating in all directions were made by surrounding mercury arc lamps with chimneys of a glass transmitting only the ultra-violet. The receiver to pick up the signals consisted of a tube containing a condensing lens, at the focal plane of which was a barium-platino cyanide screen, the full diameter of the tube. An eye-piece was mounted on a metal strip across one end of the tube. A range of 4 miles was found possible.

Traffic.—Luminous phosphorescent substances such as those used in recent years to make watch and clock dials visible at night[102] have found an important application in the war. The British used as aids to night traffic large wooden discs, 25 in. (63.5 cm.) in diameter coated with luminous paint and having a sharp point on the reverse side. These could be fixed into the ground or sides of trenches or other earth-works, or to buildings, fences or other structures, rendering them sufficiently visible to be located at a distance of from 30 to 60 ft., (9 to 18 m.) without revealing them to the enemy. They were also used in the hand for giving optical signals, or information at short distances, where silence was imperative. In a similar way luminous ribbons were placed on the backs of stretcher-bearers to prevent their being fired upon

[100] *Sci. Amer.*, Sept. 7, 1918, p. 185.
[101] *Nature*, Apr. 17, 1919, p. 138.
[102] *Sci. Amer.*, May 31, 1919, p. 571.

by their friends. Pedestrians in Paris[103] during the period of darkened streets used flash lamps to aid them in finding their way. To assist in piloting them, the entrances of buildings, lamp posts, house numbers and places of refuge were outlined with cat's eye mirrors which caught the gleam of the flash light and by reflecting it helped to identify the locality.

Lightless Nights.—According to records kept by representatives of the United States Fuel Administration,[104] the operation of the "lightless night" order resulted in the single Borough of Manhattan, New York City, in a saving on the first night of about 100 tons of coal. In one amusement park in Philadelphia, the records showed a saving of almost 3 tons. The question of enforcing the "lightless night" order at the big beaches outside of Boston brought out the fact[105] that the power consumption at these resorts is relatively small. In one case where 2,600 incandescent lamps light the boulevard, only 4 tons of coal per month were being consumed. The "lightless night"[106] order was modified on Nov. 11th for the eastern states to the extent of permitting store windows to be lighted at night as long as the store remained open for business. In California[107] where the order was expected to be in effect only during August and September, it was continued until the Armistice was signed. In October[108] the two hundred companies which had been exempted from the "lightless night" order because they used water power, were requested to comply with the same restrictions as companies burning coal.

The "lightless night" regulation in Missouri was suspended indefinitely on November 12th.[109] In general,[110] except where state administrators because of conditions local to their states felt the necessity of its continuance, the order was vacated and set aside on November 23rd by statement No. 904 of the United States Fuel Administration. Accordingly, this date, November 23rd, witnessed the release of electric signs and display lighting from the restrictions imposed by war conditions. The order was suspended in Massachusetts and Connecticut[111] in December.

103 *Pop. Mech.*, Sept., 1918, p. 347.
104 *Munic. Jour.*, Aug. 24, 1918, p. 154.
105 *Elec. Wld.*, Sept. 28, 1918, p. [illegible]
106 *Munic. Jour.*, Nov. 16, 1918, p. 395.
107 *Elec. Wld.*, Oct. 19, 1918, p. 762.
108 *Elec. Wld.*, Oct. 12, 1918, p. [illegible]
109 *Am. Gas Eng. Jour.*, Nov. 16, 1918, p. 407.
110 *Signs of the Times*, Dec., 1918, p. 29.
111 *Elec. Wld.*, Dec. 7, 1918, p. 1098.

Foreign Restrictions.—After a study of the fuel and lighting rationing-systems as applied in Great Britain and France, the English came to the conclusion[112] that their method which consisted in rationing according to the number of rooms in a house had many advantages over the French system which apportioned according to the number of people. An investigation[113] of the subject of economy of fuel and light as used in munition work in England brought out the fact that conditions in outside cities were better than those in London. The magnitude of the fuel and light requirements of one works, typical of a score, proved to be astonishing. Two hundred million cubic feet of gas, equivalent to 18,000 tons of coal per annum and 13,000,000 units of electricity were consumed in this plant.

In England, the moving-picture theatres were put on a strict rationing of light[114] and heat. Performances not well attended were considered unjustified and the number of hours open per day were reduced. From March 1918 on, theatres were closed at 10.30 p. m. A late order[115] intended to prevent too little illumination prohibited enclosed boxes and prescribed that in no part of a hall was the lighting to be of a lower standard than 0.025 footcandle and, wherever possible, lighting of a higher standard should be provided. In Ireland,[116] the Dublin Chamber of Commerce and other bodies decided to close their offices earlier during the winter in order to save lighting. In Belfast and other centers, it was planned to alter the hours for service in many churches and to have services shortened. In Ballymena, a town meeting agreed to earlier closing of shops and recommended the reduction of kitchen fires and hall lights in private houses. The Irish Lighting Restriction Order sanctioned by the viceroy[117] provided for the prohibition of all shop window and outside lighting; the closing of all offices, warehouses and shops at 5.30 on four days of the week; the permission for private premises to use two-thirds of the lighting used before the war; factory lighting to be limited to 80 per cent. of that in use in 1914; and public lighting not to exceed 50 per cent. The pro-

[112] *Gas Jour.*, Oct. 1, 1918, p. 33.
[113] *Gas Jour.*, Oct. 8, 1918, p. 84.
[114] *Elec. Rev.* (U. S.), Oct. 26, 1918, p. 664.
[115] *Ill. Eng.* (Lond.), Sept., 1918, p. 218.
[116] *Gas Jour.*, Sept. 17, 1918, p. 541.
[117] *Elec. Rev.*, (Lond.), Oct. 25, 1918, p. 397.

visions of this order were considered unreasonable and the chief Secretary for Ireland undertook to have them removed which was later done.

Owing to the differences in climatic conditions and the longer lighting hours, a separate household fuel and lighting order was made for Scotland to go into effect October first.[118] Nine thousand cubic feet of gas was allowed per year for houses where the number of rooms did not exceed three. In various parts of England it was recommended[119] that during the summer, the street lighting be reduced to 50 per cent. of its pre-war intensity, the reduction being so made as to make main thoroughfares indistinguishable from side streets. In the Metropolitan Borough[120] of London, it was recommended that the street lighting be made more uniform in main and side streets, and that for vehicle lighting no portion of the beam should fall outside a plane parallel and 42 in. (1.1 m.) above the roadway measured at a distance of 100 ft. (30.5 m.) from the vehicle; that there should be sufficient light to distinguish a person or object at a distance of 100 ft. (30.5 m.). In the Westminster District[121] arc lamps were replaced by 100-watt, gas-filled tungsten filament lamps to decrease the lighting. Subsequently, it was decided to reduce[122] by another 25 per cent. the lighting allowed in hotels, restaurants and large shops in London and the big provincial towns.

In normal times, the main sources of light in Denmark[123] are gas, electricity and petroleum, but the lack of coal, as well as petroleum, just before the termination of the war brought the lighting problem to such a crisis that the government purchased 400 tons of tallow for the purpose of making candles. On the other hand, more than one hundred ships were supplied with acetylene lanterns, and the use of acetylene for general lighting grew so, that as many as 180 types of lamps were at one time on the market. Alcohol, which is a Danish product has also come into the field through the invention of a lamp which burns in much the same manner as the incandescent gas light. It was noted[124] that in 1918 in Berlin, the prescribed economy to 80

118 *Gas Jour.*, July 2, 1918, p. 16.
119 *Gas Jour.*, Aug. 6, 1918, p. 260.
120 *Gas Jour.*, July 30, 1918, p. 220.
121 *Elec. Rev.* (Lond.), Aug. 2, 1918, p. 109.
122 *Elect. Rev.* (Lond.), Nov. 22, 1918, p. 493.
123 *Sci. Amer.*, Sept. 28, 1918, p. 263.
124 *Ill. Eng.* (Lond.), Aug., 1918, p. 202.

per cent. of the 1916 amount of gas was not attained. As a consequence, the authorities contemplated fixing certain "gas-less hours" during which no gas would be supplied, and by January 1919, things had reached such a pass that the use of gas by householders was prohibited between the hours of 8.30 p. m. and 11 a. m. and between 2.00 and 5.30 p. m. Street lighting was reduced to 20 per cent. while restaurants, theatres, etc., were cut to 50 per cent. of the quantity that had been used the previous month.

Within an hour of the time at which the Armistice came into force[125] that part of the "restricted lighting" order relating to hotels, restaurants, clubs and places of entertainment was suspended in London. The masking of street lamps was removed, but the total number of lamps in use was held to one-half the normal so as to save fuel. The result was a tendency to forget that any restrictions were in force and it became necessary to call attention[126] to the fact that the main restrictions of the order were still operative, and would be until sufficient fuel had been stored up. However, in December[127] the order was relaxed to the extent of permitting shop-window lighting through the period of the holidays. In Leeds,[128] street lighting was increased in December from three hundred to eight hundred lamps, this being about half the number used before the war. In Manchester, lamps were added at the rate of one thousand a week until 10,500 were in operation, the full normal number being 21,000. A new lights (vehicle) order removed all restrictions on oil lamps, but prohibited the use of electric bulbs exceeding 24 candlepower and acetylene burners of over 21 liters (3/4 cu. ft.) capacity. In January[129] the allowances of gas and electricity for fuel and lighting in general were increased 25 per cent. in England and Wales, but not in Scotland. At Bradford where 14,000 gas lamps are ordinarily in service, only 2,500 were used during the war.[130] On December[131] first all restrictions as to the sale or purchase of calcium carbide were removed.

In order to provide spectacular effects during the peace celebration in England, the government announced[132] the suspension

125 *Elec. Times*, Nov. 14, 1918, p. 285; also *Gas Jour.*, Nov. 19, 1918, p. 407.
126 *Gas Jour.*, Nov. 26, 1918, p. 479.
127 *Gas Jour.*, Dec. 10, 1918, p. 574.
128 *Ibid*, p. 580.
129 *Elec. Rev.* (Lond.), Jan. 10, 1919, p. 47.
130 *Gas Jour.*, Jan. 14, 1919, p. 82.
131 *Elec. Rev.* (Lond.). Nov. 29, 1918, p. 519.
132 *Elec. Rev.* (U. S.), May 31, 1919, p. 884.

of all restrictions on lighting for a period of four days. In June the Controller of Mines[133] announced the necessity of continuing the rationing of coal, gas and electricity for household fuel and lighting for a further period. However, a modification of the existing order was made for consumers of less than five tons of coal in a year, 12,500 cu. ft. of gas per quarter, and 400 units of electricity per quarter.

STREET LIGHTING

The extensive use of the automobile for touring and commercial travelling[134] has increased inter-city vehicular traffic and created a demand for the development and extension of street and highway lighting, and, conversely, improved lighting has stimulated this class of traffic. Recent developments in transformers permit of the automatic control of series street lighting circuits at any distance from the power house and thus eliminate the expense attendant on constant-current control at distant points.

A recent census of lamps used for public lighting[135] in one thousand cities and towns of Great Britain and Ireland showed that of a total of 670,286 lamps, 585,550 are gas and 84,736 are electricity. From the preliminary figures of the 1917 quinquennial report on central stations[136] it appears that from 1912 to 1917, the use of arc lamps for street lighting in Kentucky, Tennessee and Nebraska decreased in round numbers by 8, 27 and 93 per cent. respectively, while the number of incandescent lamps used for this purpose increased by 106, 124 and 128 per cent.

An outgrowth of the safety work of the Bureau of Mines[137] has been the development of a new design for "safety islands" intended first to mark definitely the intersection of streets, etc., and thereby direct traffic both by day and by night; second, to minimize loss of life and serious property damage due to collisions, due to either careless driving, skidding, or otherwise; and third, to be installed at such a point and elevation as to be always in the line of vision, both by day and by night, and easily distinguished in the former case by size, color and contour, and in the latter case by light rays coming from the light source inside through slots in

133 *Gas Jour.*, June 17, 1919, p. 745.
134 *Elec. Wld.*, Mar. 15, 1919, p. [illegible]
135 *Gas Jour.*, June 10, 1919, p. [illegible]
136 *Elec. Wld.*, Mar. 1, 1919, p. 444.
137 *Elec. Rev.* (U. S.), Oct. [illegible], 1918, p. [illegible]

the housing. It consists of a dome-shaped cast iron shell, with vertical slots, resting by weight only on a concrete base. An incandescent lamp in a red globe throws light out through the openings. The value of keeping street-lighting equipment clean is recognized[138] by a company which has the contract for lighting the streets, boulevards and parks of one of the larger cities. A definite schedule is followed in cleaning globes and lamps and a special wagon crew are provided for the purpose.

Under the heading, "Influence of the War" will be found some references to street lighting while further information on street-lighting conditions and progress may be seen in the following illustrations:

Washington.—The old carbon lamps which had been in use in Spokane[139] for nearly 25 years have been, or are to be replaced by 1,410 gas-filled tungsten lamps. At Vancouver and Hoaquim improvements have been planned or installed.

California.—By taking advantage of a street railway installation on Van Ness Avenue, the engineering department of San Francisco has designed[140] special ornamental concrete poles which are used, both for trolley purposes and as electroliers. This system will replace the old one which consisted of three triple-top gas lamps per block from Market Street to Vallejo Street giving a nominal candlepower not to exceed 500 per block. Beyond Vallejo Street north, one arc lamp gave approximately 300 candlepower per block. The new arrangement includes five hundred 250-candlepower tungsten lamps located, two to the pole and sixteen to the block, giving a total per block of 4,000 candlepower. The circuits are so arranged that the lamps on alternate poles may be extinguished when desired. In Los Angeles, [a] specifications for the installation of an ornamental lighting system on one of the main streets having been approved, 134 arc-lighting standards, 27 ft. (8.2 m.) high and spaced at approximately 12-ft. (3.7 m.) intervals on each side of the street will be installed, each carrying two 1,600-candlepower arc lamps. Changes in street lighting have also been planned or made in Fresno, Red Bluff, Palo Alto, Orland, Fullerton and Hollister.

138 *Elec. Rev.* (U. S.), June 28, 1919, p. 1094.
139 *Munic. Jour.*, Nov. 9, 1918, p. 375.
140 *Elec. Rev.* (U. S.), Jan. 18, 1919, p. 102.
(a) *Jour. of Elec.*, July 1, 1919, p. 47.

Utah.—Plans are being made for the installation of a lighting system[141] along the Salt-Lake-to-Ogden highway. In Brigham City, a new series lighting system on steel poles is under construction for the business district.[142] A similar system but of the pendant type has been arranged for Main Street north and south of the business district.

Iowa.—At Clinton, 211 arc lamps[143] are to be replaced by incandescent electric lamps and twenty additional units installed which with those now in use will make a total of 303. An all-night schedule has been adopted. Changes have been made or carried out at Yorktown, Neola, Clinton, Davenport, Dubuque, and Mondamin.

Texas.—At Austin, 52 single-light, cast-iron poles have been added on West Avenue. The poles are spaced about 90 ft. (27.4 m.) apart alternately on the two sides of the street.[144] The standard equipment consists of an 8 by 16 opal globe holding a 6.6-ampere series, 100-candlepower lamp. The installation of 900 new street lamps in various parts of Dallas has been started.[145] Changes have been made also in El Paso.

Arkansas.—The "white-way" installation on Garrison Avenue at Fort Smith[146] has been completed and put into operation. It consists of 400-candlepower lamps on ornamental brackets attached to expanded steel poles placed 100 ft. (30.5 m.) apart on each side of the street. At Benton and Levee changes have been proposed or carried out.

Indiana.—At Indianapolis[147] a recommendation has been made to change from electric arc to gas lamps on three residential streets, owing to heavy foliage of shade trees which limits the effectiveness of the arcs. The replacement of arc lamps by electric incandescent lamps at Princeton[148] ordered two years ago and held in abeyance during the war has begun. Changes have been noted also at Albion, Brazil, Logansport, and Fort Wayne.

Ohio.—In Cleveland, the "white-way" system in the business district has been considerably extended. The total number of

[141] *Elec. Rev.* (U. S.). Apr. 5, 1919, p. 573.
[142] *Elec. Rev.* (U. S.), Mar. 1, 1919, p. 367.
[143] *Elec. Rev.* (U. S.), Feb. 1, 1919, p. 191.
[144] *Munic. Jour.*, May 24, 1919, p. 368.
[145] *Elec. Wld.*, Dec 21, 1918, p. 1207.
[146] *Southwestern Elec.*, Nov. 30, 1918, p. 24.
[147] *Gas Age*, May 1, 1919, p. 484.
[148] *Elec. Rev.* (U. S.), Feb. 1, 1919, p. 202.

lamps for this purpose is four hundred ninety 1,000-candlepower lamps, three hundred twenty-two 1,500-candlepower lamps with one hundred thirty being installed. The following is a list of other lamps at present in operation two hundred eighty 600-candlepower lamps; two hundred 150-watt series lamps; 628 carbon arc lamps; eight hundred ninety 4-ampere magnetite arc lamps.

At Cincinnati, the city council has adopted[149] a regulation authorizing the installation of new ornamental lamps on McMillan Street, one of the main thoroughfares of the suburban section, and the first to be equipped with such lamps. The extension of the ornamental lighting system on Vine Street to cover the entire down-town section of the city and to the suburbs, which was held up by the war, is to be finished.

At Youngstown, Hamilton, Perrysburg, Lima, Port Clinton, Marion, and Bucyrus changes have been proposed or put into operation.

New York.—An association of New York City[150] business men has inaugurated a campaign for the better municipal lighting of Broadway. A committee has been appointed to study the situation and to make recommendations to the city officials. By turning off the lights in private buildings for several minutes during a recent demonstration, the inadequacy of the present lighting was clearly shown. Elsewhere, due to unsettled conditions and the scarcity of labor and materials, lamps have been installed only in those sections of the city where it was absolutely necessary. The number of lamps in service is practically the same, but certain changes have been made in the types and sizes, a number of 400-watt lamps having been dropped, 100-watt and some 125-watt lamps having been added. Activity in street lighting has been noted also in Brooklyn, Syracuse, Rensselaer, Andes, Belmont, Mineola, Dunkirk, Leroy, Glens Falls, Saratoga Springs, and Hornell.

Connecticut.—An excellent solution of the problem of lighting a city of small size has been worked[151] out in South Norwalk. The general plan followed was to settle upon a standard form of prismatic refractor combined with a frosted bowl to improve its

[149] *Elec. Wld.*, June 14, 1919, p. 1307.
[150] *Elec. Wld.*, June 28, 1919, p. 1411.
[151] *Elec. Wld.*, Mar. 22, 1919, pp. 567 and 575; also *Munic. Jour.*, May 3, 1919, p. 320.

appearance and to reduce the glare when viewed from a point near the pole. A hole in the bottom of the bowl gives ventilation and permits dust and insects to fall out. Double-fixture poles were adopted with a standard height of 15 ft. (4.6 m.) and spaced oppositely every 100 ft. (30.5 m.) in the more important business districts, and alternately in residential streets. In outlying districts where the ornamental fixtures were unnecessary, refractors were still installed but new brackets were put up. The lamps used were 6.6-ampere series incandescent ranging in candlepower from 250 to 80. The advantages claimed for the installation are: obtaining the best illumination possible with available designs of fixtures at an initial and operating cost much less than is usual with ornamental systems; the system is ornamental by day as well as by night; the intensity of illumination is high enough for cities of average size and yet does not call for the large amount of power needed for so-called "white-way" lighting.

Massachusetts.—Work has been started[152] on the installation of new street lamps to replace the old system in Brockton. Sixty-candlepower gas-filled tungstens are to replace 16-candlepower carbons in the out-lying-districts. Over 300 lamps of the 600-candlepower type will replace 206 arc lamps in the main part of the city. Some ornamental lamps will be used of 1,000 candlepower capacity mounted in crystal globes on standards similar to those used for the lighting system at the Panama-Pacific Exposition.

The following table shows the number of lamps in operation in the city of Boston:

Magnetite arc lamps	800 candlepower	Series	5258	(including 242
" " "	500 " "	Multiple	26	white way)
		Total	5284	
Incandescent	40 candlepower	Series	1857	
		Multiple	1443	
	60 candlepower	Series	786	
		Multiple	505	
	100 candlepower	Series	3	
		Multiple	9	
	500 candlepower	Multiple	10	
Gas				
Open flame fire alarm			144	
Single mantle			9715	

152 *Elec. Wld.*, Dec. 21, 1918, p. 1206

Baltimore[153] maintained 20,419 lamps during the past year, 567 having been added. 1119 "white way" ornamental posts have been overhauled and repaired. The question of lighting dark alleys has been considered and 59 lamps installed to cover this need.

Changes have been planned or carried out in Dana, Methuen, Worcester, West Brookfield, Holyoke, Brookline, Leominster, Shrewsbury, and Webster, Massachusetts.

In addition to the specific cases cited, the installation of a system of street lighting, the replacement of one type by another, increases or other changes have been planned or provided for in the following cities of Connecticut: Milford, Danbury; of Delaware: Summit; of Florida: Crescent City; of Georgia: Summerville, Lyerly; of Kansas: Niles, Verdi, Louisville, Downs, Topeka, Eldorado, Wichita, Independence, Neodesba, Hominy, Liberal, Herndon, Osawatomie, Great Bend; of Maine: Bristol; of Minnesota: Aldrich, Kelly Lake, St. James, Ironton; of Illinois: Springfield, Mattoon, Jacksonville, Weldon, Rock Island, Marion, Uubana; of Michigan: Lansing, Boyne City, Hancock, Tipton, Holt, Lapeer, Port Huron, Coldwater; of Kentucky; Lexington; of Alabama: Anniston; of Missouri: Marshfield, Kansas City, Lowry City, Miller, Aurora, Marshall, DeWitte, Carthage; of Montana: Kalispell, Dillon; of Nebraska: Omaha; of New Hampshire: Manchester; of New Jersey: Clifton, Patterson, Nutley, Jersey City, Irvington, Newark, Trenton, Perth Amboy, Dover, West Orange; of North Carolina: Freemont, Durham; of North Dakota: Munich, Minot, Mandan; of Oklahoma: Frederick, Muskogee, Cushing, Commerce, Tulsa; of Mississippi: Yazoo; of Pennsylvania: Eldersville, Harrisburg, Beaver Falls, Athens, Farrell, Allentown, South Brownsville; of Rhode Island: Pawtucket; of South Carolina; Spartansburg; of Vermont: Springfield, Montpelier; of Virginia: Staunton, Richmond; of West Virginia: Moorefield, Wheeling; of Wisconsin: Appleton, Green Bay, Beloit, Beaver Dam, Superior, Manitowoc, Duluth; of Tennessee: Lafayette, and of the following Canadian towns: of Ontario: Wingham, Chippewa; of Saskatchewan: Cabri; of Nova Scotia: Barrington; of New Brunswick: Marysville.

153 *Munic. Jour.*, Aug. 16, 1919, p. 107.

Foreign.—During the war,[154] the 496 arc lamps in the Hackney district of London were replaced by 32-candlepower carbon incandescent lamps in order to comply with the restrictions. The electrical committee has recommended that 404 of the arc lamps be not reinstated, but replaced by 600-candlepower gas-filled tungsten filament lamps. Oxford,[155] is said to be the first city in England to use refractor globes in street lanterns. The main streets are illuminated by 300-watt tungsten filament lamps in ordinary arc-lamp posts, 22 ft. (6.7 m.) high. The spacing ratio varies from 7.9 to 13 and the maximum and minimum illuminations are 0.495 and 0.072 footcandle with 0.028 footcandle at the street level. While under Turkish control[156] the street lighting of Damascus was disused for weeks. The first act of the restored Arab administration was to put the lighting plant into operation. The municipal[157] corporation of Calcutta has decided to extend the gas lighting system.

OTHER EXTERIOR ILLUMINATION.

A novel idea for utilizing the flood-lights[158] which have made night work possible in shipyards of the northwest is suggested by the warden of the Oregon penitentiary. He wishes to have some of them to save extra guard hire and to prevent escapes, each of which are quite expensive for the state. Methane, or marsh gas as it is ordinarily called, has been used[159] to light a mill-pond by simply forcing a barrel down to the decayed vegetable matter and running up an ordinary pipe from the barrel top. A mantle burner completes the equipment.

Displays.—Since the signing of the Armistice, decorative lighting has been a prominent feature throughout the country and particularly in the large cities. The jeweled arch erected in New York[160] in honor of the returned soldiers was held by some to surpass anything at the Panama-Pacific Exposition in the use of electric lighting for elaborate and artistic effects. The arch was compared to a gigantic curtain of jewels drawn between two

[154] *Elec. Rev.* (Lond.), Dec. 20, 1918, p. 630.
[155] *Elec. Times*, Jan. 9, 1919, p. 24.
[156] *Elec. Times*, Oct. 24, 1918, p. 250.
[157] *Gas Jour.*, Oct. 15, 1918, p. 140.
[158] *Jour. of Elec.*, Mar. 1, 1919, p. 226.
[159] *Gas Age*, Oct. 15, 1918, p. 340.
[160] *Elec. W'ld.*, Apr. 5, 1919, p. 696.

obelisk forms. The latter rose to a height of 80 ft. (24.4 m.) and were surmounted by great jewelled forms in the shape of sunbursts 12 ft. (3.7 m.) wide and 20 ft. (6.1 m.) high. Approximately 30,000 jewels from the famous Tower of Jewels of the Exposition were used in the curtain. Beams of light from a battery of arc projectors caused the jewels to glisten and sparkle with all the colors of the spectrum. Many of the signs and devices[161] worked out to aid in the "Welcome Home" movement were of striking nature and of a character to indicate permanency. In New York City on the front of a theatre was a cluster of myriad lamps so grouped as to flash out all the allied emblems in their natural colors, topped by an American eagle guarding a shield. The equipment for one of the large buildings consisted of over five thousand 10-watt lamps, the entire building being outlined with 2-ft. stars, each star containing eleven lamps.

The annual Rose Festival in Portland,[162] Ore., was made the occasion for the "Victory" celebration. For the display lighting 250 red, yellow, pink, and white roses were constructed of sheet metal, each carrying a 1,000-watt frosted gas-filled lamp in the center. They were 3 ft. (0.9 m.) in diameter and ventilated to dissipate heat, and were distributed along fifty city blocks. Streamers containing three thousand 50-watt carbon "ruby" and 10-watt clear tungsten lamps were installed. On the arch erected at the station were forty 75-watt lamps. Five hundred 10-watt lamps were used on the arch at the Festival Center. The "Brighten Up" campaign spread throughout the country.[163] The lighting and installation of signs and special patriotic displays, the flooding of streets and shop windows with light without stint, produced an inspiring and uplifting effect which did much to restore cheerfulness and optimism. A shining example was set in Washington where the flood-lighting of the Capitol, discontinued shortly after our entrance into the war was resumed.[164]

In Chicago, a "Victory Way" was established,[165] the lighting of which was made most elaborate and spectacular. The street-lighting posts on both sides of the streets were equipped with red, white and blue globes, and on the top of each post a golden

[161] *Elec. Rev.*, Jan. 25, 1919, p. 151.
[162] *Jour. of Elec.*, July 15, 1919, p. 60.
[163] *Signs of the Times*, Feb. 1919, p. 26.
[164] *Ibid*, p. 30.
[165] *Elec. Rev.* (U. S.), Apr. 26, 1919, p. 672.

goddess of Victory was placed. One hundred and seventy-five flood-light projectors containing 500-watt lamps were scattered along the way on the roofs of office buildings and in their windows. A brilliant, scintillating "Altar of Victory" was erected at the central part of the Way. It was composed of two enormous candelabra, erected one on each side of a platform 90 ft. (27.4 m.) high by 8 (2.4 m.) square. These were studded with jewels and supported a curtain of jewels suspended above the altar. In the center of the curtain was a huge jeweled eagle bearing the allied flags. The jewels were similar to those used at the Panama-Pacific Exposition and were especially illuminated by three open arc projectors rated to deliver 200,000,000 candlepower. In addition to the light from these projectors, the altar was illuminated by numerous small projectors on the platform and at other points. In the top of each candelabra were six 500-watt red and orange-colored lamps, equipped with reflectors. Live steam issued from the top where these lamps illuminated and tinted it. Over all was a large luminous fan formed by beams from 18 in. (45.6 cm.) arc searchlights.

A high tower offers an exceptional opportunity for display lighting and advantage of this fact has been taken in a new 34 story[196] building. A row of windows each 4 ft. high by 14 in. wide extends around the tower and thirty-six 400-watt and eight 200-watt projector units on the inside will throw light out of the windows in what will appear to be a continuous band. The value of adequate public lighting and the importance of a quick return to normal conditions was recognized[197] early this year in England where protest was made against maintaining restrictions a moment longer than the fuel shortage necessitated.

Transportation.—In the Report of the Committee on "Lighting Layout for Engine Terminals and Yards" of the Association of Railway Electrical Engineers particular attention is given to the use[198] of floodlighting equipment for this class of illumination. Floodlighting permits of economy of installation and maintenance and the report covers its application to classification yards and engine terminals, including clinker pits and roundhouse circles.

196 *Elec. Rev.* (U. S.), July [illegible], 1919, p. [illegible]
197 *Gas Jour.*, Jan. 14, 1919, p. 71
198 *Rwy. Elec. Eng.*, Oct., 1918, p. [illegible]

In the course of a discussion[169] before the London Illuminating Engineering Society on outside railroad lighting, it was brought out that where incandescent gas lighting is employed, there is an unmistakable tendency to standardize a small mantle, generally the "medium" or No. 2 size, which allows of ample flexibility in the candlepower of units by the use of one, two or more mantles in a lamp. In the case of incandescent electric lamps, the standardizing has been extremely difficult owing to the large number of different supply companies, each with its own special voltage. On one railway there are twelve different pressures, ranging from 100 to 600, and a complete series in ten volt steps from 200 to 250. Definite standards for platform illumination seem to be crystallizing and minimum figures of 0.5 ft. candle were suggested for terminal stations and 0.25 for secondary stations. Considerable stress was laid upon the importance of illumination ratios, that is the ratio of minimum to maximum illumination, since it is a criterion of uniformity, said to be highly desirable in this class of lighting.

Better illumination is credited[170] with being one of the main factors in cutting the time of hull construction in the shipyards of the northwest from 8 months to 60 days. In one plant general overhead illumination is furnished by fifty 1,000-watt units in goose necks which can be raised and lowered 20 ft. (6 m.), and wired one lamp to a circuit. Midway illumination is produced by seventy-two 500-watt lamps fastened to staging 40 ft. (12.2 m.) from the ground and wired two to a circuit. Lower-level illumination is produced by two hundred and fifty-nine 60-watt lamps and sixty 500-watt temporary lamps are used to light the underside of the hull. In addition, fourteen 1,000-watt floodlights are available. A recently installed system[171] for lighting ships when being loaded or unloaded is made up of lamps mounted on poles on the dock, 60 ft. (18.3 m.) above the floor and far enough apart to range the entire deck length of a large freight ship. The dock side of each lamp is masked by a reflector so that all the illumination is thrown on the ship's deck. The light is diffused and the lamps are so high as to avoid glare which formerly had been the cause of accidents. An excellent description of modern prac-

[169] *Ill. Eng.* (Lond.), Mar., 1919, p. 59.
[170] *Jour. of Elec.*, Apr. 1, 1919, p. 298.
[171] *Pop. Mech.*, May, 1919, p. 682.

tice in the lighting of ore docks[172] is to be found in the 1918 Report of the Committee on Docks of the Association of Railway Electrical Engineers.

During the war[173] various devices were used to guide air-men in night flying. The British relied chiefly on land lighthouses, each flashing a different code number as an indication of locality. The Germans used also permanent colored flares, stationary searchlight beams and "flaming onion" sprays flung upward to an immense height. The problem is one which has by no means been eliminated and the best solution will be required in the not distant future.

Commercial Illumination.—A significant item[174] occurs in the Report of the London "Safety First" Council, a body which is made up of representatives from most of the large London boroughs, and various other local authorities. It is to the effect that the return of pre-war lighting of the exteriors of shops should be "subject to the important qualification that diffused lighting on scientific principles" be substituted for glaring naked lights and there should be elimination of the sudden transition from comparative brightness to darkness, and *vice versa*, which formerly obtained in the streets of the metropolis.

In the Progress Report for 1915, reference was made to the use of brilliant illumination as a means of selling real estate at night. A modification of this idea[175] was used by a real estate man in a western city who installed a number of gas arcs in front of a row of new stores and kept them burning all night. This same method has been used in the east with good success. Evidence of the efficiency of floodlighting in connection with fire-fighting[176] is reported from Scotland where the firemen of Dundee used a 1,000-watt unit which threw a beam so powerful that they were able to identify one of their members working at a height of 400 ft., (122 m.).

Agriculture.—Some time ago a number of farmers emigrated from other parts of the country and went to live in a county of Mississippi, where they have introduced[177] what is claimed to be

172 *Rlwy. Elec. Eng.*, Oct., 1918, p. 327.
173 *Ill. Eng.* (Lond.), Feb., 1919, p. 52.
174 *Elec.*, Mar. 21, 1919, p. 334.
175 *Am. Gas Eng. Jour.*, Mar. 15, 1919, p. 229.
176 *Elec. Rev.* (U. S.), July 19, 1919, p. 97.
177 *Elec. Rev.* (U. S.), May 31, 1919, p. 899.

an innovation in farm life in the south, that is, the use of electricity for lighting and other purposes throughout an entire farming section which is also linked up by macadam roads. Overseas shipment of fruit[178] from the Canadian northwest is responsible for a decided novelty in fruit-picking. In searching for a cause of rotting in shipped fruit, it was finally concluded that the question of temperature at the time of picking was the controlling factor, and consequently, daytime picking was undesirable. An electric company in the Saskatchewan district arranged to furnish current to orchards along its lines. Movable floodlighting units were employed and the picking was done after the cool of the evening had set in with what is reported as being very satisfactory results. Experiments by the Agriculture[179] Department of one of the large universities indicate that in poultry husbandry when artificial light is properly applied to the right kind of stock in connection with correct methods of feeding the distribution of egg-production throughout the year can be radically changed, increasing the supply of fall and winter eggs and decreasing the supply during spring and summer. Data on the amount of light required for a given amount of floor space and on different methods of illumination are to be published when the experiments are completed. It is said that the most satisfactory results have been obtained when illumination has been applied from dusk until nine o'clock the year around. The advantage of the small self-contained electric lighting plants such as those used on farms has been recognized in logging[180] camps and a considerable number have been installed in the past two years. The equipment serves to light yarding camps, cookhouses, and bunk rooms, thus reducing the fire hazards and improving the ventilating conditions and as a consequence the comfort and satisfaction of the employees.

Sports.—Another trap-shooting[181] club has been provided with night illumination. Two 1,000-candlepower lamps are placed in position on the ground, one on either side of the trap-house, 24 ft. (7.3 m.) back of the score. Ten 450-candlepower lamps are

178 *Elec. Merch.* Mar., 1919, p. 120.
179 *Jour. of Acet. Lighting*, Mar., 1919, p. 206.
180 *Elec. Rev.* (U. S.), Mar. 1, 1919, p. 360.
181 *N. E. L. A. Bul.*, Jan., 1919, p. 17.

placed on poles 10 ft. (3 m.) high and an all white glass clay is used which has been found to show up better than the regulation clay.

INTERIOR ILLUMINATION.

While it is true that within the last few years more attention has been given to industrial than to any other class of lighting, commercial and home lighting have by no means been neglected, and new buildings have given increasing evidence of more careful consideration of the lighting problem and its proper solution. Though the war necessitated a restriction in exterior illumination,[152] and thereby retarded, if it did not altogether block improvements in street lighting and display lighting, yet it did enormously stimulate industrial lighting and proved in factories and workshops that improved lighting means improved production, and that on a 24-hour schedule, the output at night can equal that by day. The installation of modern lighting systems has eliminated losses due to cloudiness and storms, increased the general efficiency and morale of the workmen and enlarged the production in spite of depleted and diluted forces and at a time when this intensified utilization of plants was a great boon to industry. Progressive lighting interests believe that developments achieved in this line should by all means be continued, if possible more aggressively than during the war.

Growing evidence of increased production resulting from the use of higher lighting intensities led the illuminating committee of the Ohio Electric Light Association to inaugurate[153] a campaign on behalf of improved industrial lighting. Special meetings were held and the co-operation of the Ohio State University was secured in publishing a series of technical letters on industrial illumination constituting a correspondence course on the subject.

A table[154] of present intensity standards in industrial lighting giving in great detail foot-candle values for individual processes in a large number of industries, has been made part of the Appendix to the Proposed Code of Industrial Lighting for the State of Ohio. The intensities are graded from A to G and in the code certain minimum values on the principal plan of the work, for

[152] *Elec. Rev.* (U. S.), May 17, 1919, p. 802.
[153] *Elec. Wld.*, Apr. 19, 1919, p. 824.
[154] *Elec. Wld.*, July 26, 1919, p. 185.

each grade will be made mandatory. The U. S. Fuel Administration[185] has suggested to the lighting departments of gas companies the following values for gas consumption per hour per square foot of floor area, with recommendations that they be placed before consumers.

For entrances and elevator lobbies of office and commercial buildings, hotels, restaurants, and apartment houses..	0.044 cu. ft.
For sales spaces and stores	0.044 cu. ft.
For show windows ..... for each running foot of window.	2.1 cu. ft.

The show window section[186] of the lighting exhibit at the N. E. L. A. Convention comprised a full sized window completely dressed to display furniture. Ten different effects were obtained using both clear and colored light. The section devoted to home lighting showed a living room and a dining room completely furnished in all details. Three general methods of illumination were installed, direct, semi-indirect, and indirect, using wall brackets, ceiling lights and portables. The possibility of harmony between lighting and decoration was emphasized as well as the advantage of plenty of outlets for portable lamps.

Churches and Schools.—A good illustration[187] of the use of almost wholly indirect lighting in churches is to be found in a recent installation. The necessity of placing the fixtures largely within the direct line of vision led to the choice of the indirect system. Most of the illumination is supplied by five large luminous bowl-type fixtures, each containing five 200-watt tungsten lamps with metallic reflectors. The art glass bottom of each bowl is dimly lighted with three 40-watt lamps. Wall urns are used under the balcony placed 8 ft. (2.4 m.) from the floor and containing a 100-watt lamp with a reflector to throw most of the light at an angle of 45° away from the wall. The platform is illuminated with four 200-watt lamps with concentric metallic reflectors placed in a metallic box over a slot in the ceiling. The lamps are 4 ft. (1.2 m.) from the ceiling. Precautions have been taken to conceal these units from persons sitting near the front of the auditorium. One of the large bowl fixtures is placed in the dome and used as a semi-indirect unit. In the use of gas lighting for churches and public institutions,[188] attention has been

[185] *Gas Age*, Jan. 15, 1919, p. 118.
[186] *N. E. L. A. Bul.*, July, 1919, p. 359.
[187] *Elec. Rev.* (U. S.), July 5, 1919, p. 1.
[188] *Gas Age*, Mar. 1, 1919, p. 267.

called to the desirability of replacing obsolete equipment with modern appliances and making the installations harmonize with their surroundings. The variety of direct and semi-indirect fixtures now available makes it possible to do much in this direction. A member of the Army of Occupation has sent in a statement[189] regarding the lighting of the class rooms in the technical department of a large factory in Germany. The semi-indirect system is used the unit comprising a glazed porcelain reflector and lower translucent bowl, the whole rendered dust-proof by protecting glass. The ceiling and the walls from 12 ft. (3.7 m.) upward are painted white. Special blackboard lighting is provided by 60 watt lamps suspended by chains from the ceiling and placed level with the top edge of the board. For indirect lighting four gas-filled 100-watt lamps are used, each with a separate switch. As pointed out, the impression given is that both the lighting and experimental facilities have been subjected to careful designing and apparently such class rooms are a feature of the educational equipment of a German factory, and might well furnish a hint to manufacturers in this country who have not yet made the instruction of their employees the subject of similarly careful study.

Hotels.—The lighting of two of the newest and largest hotels in New York City[190] may be taken as an example of the best of present practice in hotel lighting. In one of these hotels, the fixture design has followed the motif of the famous frescoes of Giovanni Da Udine and is pure Italian Renaissance. The main lobbies follow the spirit of a Roman atrium and a number of ancient Roman models were studied and in part copied in the candelabra which flank the doric columns at one of the entrances. The furniture and lighting equipment of each apartment is a studied reproduction of the true antique, all in harmony with the purpose of the architect. An English restaurant[191] which is entirely below ground has simulated daylight illumination by means of dummy windows of "arctic" glass. 100-watt gas-filled tungsten filament lamps equipped with metal reflectors strongly illuminate white mill board from which the diffused light strikes the dummy windows producing the effect of morning sunshine.

[189] *Ill. Eng.* (Lond.), Jan., 1919, p. 12.
[190] *Elec. Merch.*, June, 1919, p. 281.
[191] *Elec. Rev.* (Lond.), Dec. 27, 1918, p. 625.

Hanging lanterns on the interior furnish light at night if the daylight effect is not desired.

Theatres.—The system of indirect lighting using a number of different combinations of colored lights has been introduced[192] in a new theatre for the spoken art recently completed in the east. Another new theatre to be used for ordinary dramatic presentations[193] is floodlighted on the exterior by seven 250-watt lamps. The lobbies are lighted by six massive bronze-finished pendant fixtures fitted with 100-watt lamps in glass shades and studded with numerous round frosted bulbs. The main auditorium is illuminated by two rows of lamps concealed in the cove of a large panel over the center. Four hundred 40-watt lamps are used and the light is projected on to the panel from which it is diffusely reflected to the body of the house. The decorations of the panel give an effect of blue sky flecked with white clouds. The lighting has been greatly intensified by a coating of aluminum leaf placed on the panel before it was painted. Many of the most modern developments are to be found in the lighting equipment of the stage. The lighting system installed in one of the most expensive moving-picture theatres finished during the past year[194] includes sixty-eight triple dimmers which make it possible to illuminate the entire auditorium in nine distinct colors, blending almost imperceptibly into one tone. A novel effect will be gained by throwing an appropriate color corresponding to a particular scene projected upon the screen. Another example of lighting in a moving-picture auditorium is furnished[195] by a theatre whose lighting comes from artificial windows in the ceiling. Above these windows are long boxes 18 in. (46 cm.) in height painted white inside and throwing diffused light through the windows which further diffuse it. The lamps are arranged on separate circuits so as to give high, medium and low illumination. Those on the circuit giving lowest intensity are graded so as to give the most light at the rear of the auditorium and the least near the screen.

Office Buildings.—A discussion on "office lighting"[196] before the London Illuminating Engineering Society brought out that a

192 *The Inter. Studio*, Mar., 1919, p. xvi.
193 *Elec. Rev.* (U. S.), Mar. 8, 1919, p. 371.
194 *The Moving Picture World*, Dec. 7, 1918, p. 1058.
195 *Elec. Wld.*, May 17, 1919, p. 104.
Ill. Eng. (Lond.), Feb., 1919, p. 39.

notable characteristic of office illumination in Great Britain is the very low prevailing standard which, in London is very much lower than that prevailing in many large cities of this and continental countries. The importance of recognizing the classification of systems of lighting was emphasized. Data have been published[197] on the installation in a new office building where the cooperation of the architect and illuminating engineer was made a feature of the designing of the building. In those parts of the structure, such as passageways, toilets, factory restaurant and kitchen, where there are no close demands on vision, and where the decorative element was not considered important, direct lighting with open-bowl reflectors was put in. For lobbies and corridors where the decorative element plays a part, somewhat ornamental and novel equipment was installed. For large and general clerical offices a semi-indirect unit of very dense glass, scientifically designed to give efficiency and suitable distribution was chosen wth special reference to eye-protection and expense. For private offices a medium density, pressed, opalescent-glass dish carried on a three-chain hanger provided a semi-indirect, but slightly more decorative unit. The illumination test data showed values ranging from 0.5 watts per square foot of floor space in the restaurant to 1.5 in the general clerical offices, and 2.8 in the executive offices. The ceiling height throughout was 13 ft. (4 m.) and, with a few exceptions, the lamps are 10 ft. (3 m.) from the floor. The illumination readings were made at the usual height, 30 in. (76 cm.).

As a result of discarding wall brackets and replacing two old dome fixtures which had been inverted and used as semi-indirect units, with two luminous-bowl indirect units, the illumination on the desks in one of the rooms at the Wisconsin state capitol was increased from a minimum 1.1 and a maximum 3.8 to a minimum 6 and a maximum 12.5 foot-candles.[198] At the same time the energy consumption was cut down from 2,240 to 2,000 watts and still further to 1,500 with but little loss in illumination, by painting the center panels of the ceiling white. The lighting system of the new city hall in San Francisco[199] has a number of interesting features. At the main entrances are ornamental standards with

[197] *Elec. Wld.*, Feb. 15, 1919, p. 316.
[198] *Elec. Wld.*, May 31, 1919, p. 1172.
[199] *Elec. Rev.* (U. S.) Apr. 26, 1919, p. 668.

an upper part shaped like a bishops' crook bearing an ornate lantern with crystal panels and containing a frosted 1,000-watt lamp. The rotunda is lighted by four thirteen-light standards, each set off with cut crystal globes enclosing frosted lamps. One of these standards is placed in each corner of the rotunda. The corridors on the main floor are lighted with massive bronze brackets weighing 40 lbs. each and surmounted by a stalactite containing a 1,000-watt lamp. The Council Chamber is illuminated by eight ornamental bronze candelabra chandeliers. Each carries sixteen 40-watt round-bulb frosted lamps. Special cove lighting is provided for the concave surface of the dome and a 1,000-watt lamp is placed in the observation tower at the top of the dome.

Factories.—For factory buildings[200] of the standard type, standardized lighting arrangements and equipment would seem logical. Data on the layout for certain classes of such buildings comprising ten types with bays and both high and low roofs have been made available. The standard reflector adopted by the Association of Manufacturers of Electric Supplies referred to in last year's report, is specified throughout and in the computations the footcandle requirements have been placed within the range 2 to 8. The industrial section of the lighting exhibit at the N. E. L. A. Convention was represented by a room fitted up to represent a small machine and repair shop. Three separate and independent systems of lighting were installed to show poor, fair and good practice, and to bring into marked contrast prevalent bad conditions with modern systems employing productive intensities. A dual system of wall finish demonstrated the effect of white paint in increasing the utilization of light and in producing more cheerful surroundings.

An example of up-to-date Canadian practice in factory lighting by electricity is to be found[201] in that of a knitting mill. Rooms devoted to sewing machine work are equipped with deep-bowl steel-enameled reflectors with 60-watt lamps mounted 7 ft. (2.1 m.) from the floor. The distribution is uniform with marked absence of shadows and the units are so placed that it is impossible for the operators to get glare in their eyes. It is claimed that this general lighting is superior to individual lighting for each opera-

[200] *Elec. Wld.*, July 12, 1919, p. 69.

[201] *Elec. Rev.* (U. S.), Jan. 25, 1919, p. 128.

tor. Two night lights for each floor are mounted on the ceiling and with 60-watt lamps furnish enough illumination for the watchman to make their rounds without the use of a lantern. A very considerable improvement[202] in lighting the upper floor of a cotton mill by gas was obtained by changing over from the flat-flame burner to a high-pressure incandescent mantle system. Three sets of pipes are used, one supplying high pressure gas, one carrying air to an injector, for mixing with the gas, and a third supplying the mixed air and gas to burners. Each individual burner has a gas injector and intake. But one injector is used to supply a group of burners, and all air required for consumption is drawn in from outside the building, thus avoiding the dust or fluff likely to be present in such a mill. In another spinning mill[203] a direct lighting system using electric lamps, was tried out in one part of the factory. 60-watt units with extensive reflectors were mounted 4 ft. (1.2 m.) above the bar of the loom and equally spaced along it while the rear was illuminated by a 60-watt lamp, but shadows made the result unsatisfactory. A change was made by installing two 100-watt lamps in semi-indirect 11 in. (28 cm.) glass fixtures. To provide for the portable lights a drop was hung over each loom to be used primarily for trouble lamps, but ample intensity and absence of shadows made the latter unnecessary. Although industrial lighting has improved greatly within the last few years, much remains to be done.[204] Attention has been called to the need for better lighting in central stations around the circuit breakers and switches. The use of ceiling lights in such locations often produces bad shadows which could be eliminated by units placed near the floor level.

Transportation.—The United States Railroad Administration has issued specifications[205] governing the electric lighting for the United States standard railway equipment. These specifications were formulated by six electrical engineers working in connection with a sub-committee from the committee on standards for cars and locomotives of the Railroad Administration. They provide for 32-volt, 50-watt lamps for center deck fixtures and 15 watts for door and desk lights; the 60-ft. cars are to be equipped with

[202] *El. Eng.* (Lond.), Apr., [illegible] p. [illegible]; also *Gas Jour.*, Apr. [illegible], p. [illegible].
[203] *Elec. Wld.*, Oct. [illegible], p. [illegible].
[204] *Elec. Rev.* (U. S.), Dec. [illegible], p. [illegible].
[205] *Rway. Elec. Eng.*, Nov., 1918, pp. 342, 343, 3[illegible].

75-watt lamps on the center line of the ceiling. In England, in the last 30 years railway coach illumination[206] has increased from less than 0.1 footcandle under colza oil lamps and later 0.25 footcandle under flat flame gas burners to 1.65 under inverted mantle gas burners or incandescent electric lamps with a present tendency to go to still higher values.

There is a need for a lantern especially designed for use in railway box cars when being loaded. A make-shift arrangement[207] which has met with favor consists of an ordinary kerosene lantern fitted with an incandescent lamp socket, inside the globe, attached to an extension cord. It is claimed that this unit can be hung anywhere and the bulb is not apt to be broken. The lighting on the inside of railway signal towers involves[208] the problem of glare and eye adaptation. As a result of the use of all kinds of improvised screens and shades by the operators, an English railway company has adopted a system in which the lamps are shaded by metal cylinders 4 in. (10.2 cm.) in diameter and 8 in. (20.3 cm.) long, having a longitudinal slit through which a narrow beam of light illuminates the switch handles, block instruments and train-register books, but avoids reflections at the windows and keeps the rest of the room in darkness. A compact lighting plant[209] for tug boats consists of an impulse-type steam turbine and an electric generator combined to form a single unit. It provides enough power for fourteen or more lamps and a searchlight.

FIXTURES.

The effect which the name applied to an object will have on its use and development is hard to forecast. It has been suggested[210] that the choice of the word "fixtures" to describe the lighting equipment in a room may have exerted an unfortunate influence in educating the public to think of them as fixed and unchangeable, whereas, the expression "lighting furniture" would have been much better and enabled the idea of "periods" in designs to be better understood, and emphasized the desirability of having the lighting units uniform and consistent with the rest of

[206] *Ill. Eng.* (Lond.), Mar., 1919. p. 59.
[207] *Rlwy. Elec. Eng.*, Jan., 1919, p. 2.
[208] *Ill. Eng.* (Lond.), Apr., 1919, p. 108.
[209] *Elec. Eng.* (U. S.), May, 1919, p. 206.
[210] *Elec. Merch.*, June, 1919, p. 281.

the fittings. Like furniture, the lighting equipment should be changed when it gets out of style. Again, attention has been called[211] to the way in which people turn off the light from portables and small decorative lamps for the sake of saving lighting bills, thereby losing the artistic effect with a cost saving not comparable to the interest on investments in pictures and other decorative features. Repeatedly the desirability of a revolution in the method of displaying lighting fixtures has been referred to.[212] The experience of a woman who tried to buy fixtures for a new home from a dealer who showed her through rooms so crowded with samples that she became bewildered, led her to suggest that lighting fixtures like dresses should be displayed one at a time and in appropriate surroundings.

The predominating feature of the fixtures designed for home and office lighting is the use of the semi-indirect principle and an elaboration of design.[213] More attention is apparently being paid to the subject[214] of ceiling fixtures and numerous designs for this class have been worked out.

Reflectors.—There seems to be no cessation in the output of designs for two-part units both for industrial and commercial use. A reminder of the dining-room "dome" type of fixture is found in a new unit which[215] by the addition of an under bowl shuts off a view of the interior and cuts out glare from the lamps. Several fixtures have appeared[216] in which the upper part is hollowed like part of an inverted cone, while a flat or bowl-shaped piece of diffusing glass forms the bottom and not only diffuses light downward, but being separated by a small distance from it, reflects light to the cone which acts as a false ceiling. A single rope cord may be used as a support or an ordinary stem, and a cloth shade may be suspended from the upper part, where the fixture is used in dwellings. One of the features is the ease of cleaning.

A unit which makes possible any of the three types of illumination, direct, indirect, or semi-indirect,[217] has an upper reflector

[211] *Elec. Merch.*, June, 1919, p. 289.
[212] *Elec. Merch.*, Dec., 1918, p. 262.
[213] *Elec. Rec.*, Dec., 1918, p. 45.
[214] *Elec. Rec.*, Dec., 1918, p. 38, and July, 1919, pp. 13, 14.
[215] *Elec. Rec.*, May, 1919, p. 305.
[216] *Elec. Wld.*, March 15, 1919, p. 557.
[217] *Elec. Wld.*

which is oblong and has sloping sides either of metal or glassware with metal edges with opalescent glass lining. The lower reflector is also made of metal or glass. Placed in the top of the upper section is an inverted reflector whose outside forms a portion of the upper reflector and whose inside serves to direct light to the ceiling. Two bulbs are used, one in the ceiling reflector and a larger one attached to a socket in the bottom of the ceiling reflector but enclosed by the lower section. They are controlled by separate pull switches. Indirect illumination is obtained by using the top light, while direct and semi-indirect comes from the lower bulb through the open bottom of the lower reflector and from the sides of the ceiling reflector. A difference in distribution of the reflected rays may be obtained by raising or lowering the lower reflector. An enclosed lighting unit[218] for which especially high efficiency and absence from glare is claimed is made in several styles for mounting on the ceiling and for single or multiple chain suspension. Either metal or opalescent glass may be used for the top section. The unique part is the lower which is corrugated, that part which is visible to the eye being frosted and the rest clear glass.

A new fixture intended for the better class of stores, offices, banks, etc.,[219] uses chemically treated lead glass. The bowl is 11 in. in depth by 17 in. in diameter (28 by 43 cm.), and is designed to keep out bugs and dust and to be easily cleaned. A totally enclosed indirect lighting unit[220] designed especially for hospitals is made with a 14 in. (36 cm.) crystal glass bowl, the lower half being clear to permit of the reflection of light from a porcelain enameled reflector which is fitted closely under the lip of the bowl. The fixture-stem is one piece from glass to ceiling, making an unbroken line without seams or crevices, sharp edges or corners. It is made for lamps from 40-watt to 200-watt capacity and is claimed to be dust, moisture, and bug proof. Another fixture is a combination of a porcelain enamelled holder and shade masking a one-piece ceiling unit. It is designed for a 100-watt lamp.

Industrial Units.—In spite of the efforts of lamp manufacturers to reduce the number of different sizes of lamps, there are still so

218 *Elec. Wld.*, Oct. 12, 1918, p. 722.
219 *Elec. Rec.*, Nov., 1918, p. 30.
220 *Elec. Rec.*, June, 1919, p. 372.

many that the problem of the maker of fixtures and glassware is by no means simple. One solution is[221] that found in an all-metal totally indirect unit which has a 20 in. (51 cm.) bowl of steel, coated inside and out with a white porcelain enamel. The contour of the bowl has been especially designed to produce a high-efficiency illumination. The bowl holder is readily adjusted to the proper position corresponding to any gas-filled tungsten lamp from 75 to 1,000 watts. This is accomplished by means of a sliding collar, the supporting rod being calibrated for the various lamp sizes. Another lamp manufacturer,[222] instead of making a lighting fixture which is adjustable to different sizes, has developed units for each of the standard sizes of gas-filled tungsten lamps. As a result of thus designing the unit around the bulb, it is claimed perfect diffusion is obtained for all sizes since the lamp filament in each unit is in the correct position. The unit is made in one piece of frosted glass between layers of clear glass. A modification of the metallic shallow-bowl reflector[223] with a cap over the base of the lamp which is used in industrial lighting, replaces the cap with a central dust proof globe formed of glass, the upper half of which is clear and the lower frosted, the lamp being placed inside the globe. The enormous increase in our merchant shipping has stimulated interest[224] in ship fittings and special reflectors and switches are being designed for this class of service. In many places where there are corrosive fumes, extra glassware fastened so as to be vapor-proof is employed.[225]

Portables.—A combined lamp and smoking set has been designed[226] by using a French "seventy-five" shell as a base with a reflecting shade shaped like a helmet. The shell is cut into four sections which form the smoking set. This sectional construction affords a number of different heights since one, two, or three parts may be removed and the lamp still used. To provide enough light to see to move about with, but not enough to disturb a sleeping person, there has been designed[227] a small all-porcelain white glazed lamp with a transformer device in the base. A

[221] *Elec. W'ld.*, Sept. 14, 1918, p. 522.
[222] *Elec. W'ld.*, Mar. 22, 1919, p. 609.
[223] *Elec. W'ld.*, June 7, 1919, p. 1246.
[224] *Elec. W'ld.*, Dec. 14, 1918, p. 1154.
[225] *Elec. Rec.*, Nov., 1918, p. 14.
[226] *Elec. W'ld.*, May 31, 1919, p. 1194.
[227] *Elec. Rev.* (U. S.), Apr. 20, 1919, p. 26.

2-candlepower 6-volt lamp is used and the outfit is designed for nurseries, halls, bedrooms, and wherever a night lamp is needed. A new portable lamp[228] is not only fitted with the usual wire guard with hooks on the end and side to enable it to hang anywhere, but it is mounted on a heavy piece of insulating material in the shape of a hemisphere which keeps the lamp upright when placed on a table or other flat support, and by permitting free oscillations should help in preventing breakage due to accidental blows. A special fitting[229] has been designed for lighting gauges of boilers, transformers, etc. In order to get the effect of the old-fashioned candle on the Christmas tree,[230] a candlestick has been designed which takes the lamp used in the ordinary incandescent equipment, and is readily attached by means of a clip to the branches of the tree.

Floodlights.—In a new floodlighting unit,[231] the reflector partly surrounds the lamp and makes possible a distribution covering 24° and a claimed effective use of 75 per cent. of the lamp's energy. Another type of floodlighting unit[232] is unique in having the lamp mounted 30° back of the vertical to permit pointing the projector almost straight downward from the top of the building for lighting the adjacent ground. This may be done while still leaving the lamp in proper position, namely, within 45° of the vertical, base up. A 12 in. (30.5 cm.) reflector is provided and fitted with a 250-watt unit.

Automobile Lights.—A combination light and mirrorscope has been developed for use[233] on the front fender of an automobile. In the daytime the mirrorscope is raised to the vertical position and the lamp is cut out of circuit. At night when the automobile is standing still, the mirrorscope is lowered to the horizontal position showing the lamp through a lens of red glass in the rear and white glass in the front.

Street Lighting.—Experimental work carried on in connection with a street-lighting installation[234] using lanterns has shown

228 *Elec. Rev.* (Lond.), June 27, 1919, p. 773.
229 *Elec. Wld.*, Nov. 9, 1918, p. 915.
230 *Elec. Wld.*, July 5, 1919, p. 51.
231 *Elec. Wld.*, Nov. 9, 1918, p. 915.
232 *Elec. Rev.* (U. S.), May 17, 1919, p. 820.
233 *Elec. Merch.*, Sept., 1918, p. 136.
234 *Elec. Wld.*, May 10, 1919, p. 951.

that it is possible to modify certain fixtures so as to secure a better distribution of light. The result is accomplished by collecting the upward rays by an inverted pyramid type of reflector and the lower rays by a parabolic reflector and diverting them into useful directions, preferably parallel with the street or drive. The complete lantern is constructed entirely of cast iron and glass, including the reflectors which are white fire-enamelled and not affected by heat or rough usage. The reclamation of old arc-lamp fixtures and their employment for gas-filled tungsten lamps is not new, but the details of the changes made differ and are not often available. An instance has been reported[235] of the conversion of 1,800 inclosed arc-lamps into fixtures for 400-candlepower multiple and 600-candlepower series incandescent lamps. The compensators for the series lamps were made up of pieces of scrap transformer iron wound with magnet wire. The saving effected was said to be nearly 50 per cent. of the best price at which lamps of equal quality could have been purchased. A special glass bracket fixture[236] for attaching to the casing of the arc-lamp, has been developed to enable the substitution of incandescent electric lamps in place of arcs in locomotive headlights.

Accessories.—The German Association of Lighting Technique has taken steps[237] toward the unification of the nomenclature of light sources. They have also experimented with the diffusing properties of globes used to cut down the intrinsic brightness of sources and have found opaline globes to be very much superior to those of the roughened glass type. In England[238] the use of silica or translucent quartz for chimneys and cups for gas-light burners has increased. Various types of self-adjusting arms have been designed[239] for use in connection with factory units of the single-lamp type which may be attached to the wall, suspended from the ceiling, or fastened to the floor standards, the arms being so constructed as to make it possible to hold the lamp reflector in any desired position. Improvements have been made[240] in the lamp guards used on portable hand-lamps to protect them from breakage. In one type a split handle opens to receive the

[235] *Elec. Wld.*, Dec. 21, 1918, p. 1174.
[236] *Ry. Elec. Eng.*, Nov., 1918, p. 372.
[237] *Elec. Rev.* (U. S.), Dec. 28, 1918, p. 1000.
[238] *Ill. Eng.* (Lond.), Oct., 1918, p. 239.
[239] *Elec. Rec.*, Nov., 1918, p. 41.
[240] *Elec. Wld.*, June 21, 1919, p. 1356.

lamp bulb, socket, and cord without the necessity of disturbing the wiring. Half of the guard is in the form of a metal reflector which enables the workman to shield his eyes and at the same time get more light on the work. Another guard of the all-wire type has been improved by the addition of a cushion ring which keeps the lamp bulb in the center, prevents it from touching the guard and tends to prevent breakage at the neck if the guarded lamp is dropped on the floor or struck.

A novel candle extinguisher which has proved most useful in[241] Europe operates within a given predetermined time. The bottom half of a small can is suspended above the candle by a thread which passes through a loop in a supporting wire and is then fastened to the candle at a point which will permit the given amount of burning. The extinguisher falls when the wick burns to the thread. In order to make it possible to adjust sockets and lamps to conform to the angle of any shade, a new cluster fitted[242] with sliding nipples in the wiring box has been designed for portable and table lamps. The numerous types and sizes of bowls[243] used in indirect and semi-indirect fixtures has developed a use for an adjustable hanger. One of this type has a central spider stamped out of one piece of steel and provides socket attachment arms as well as intermediate arms to support the bowl. To these latter arms are attached extension pieces which are pierced with holes 3/16 in. (0.5 cm.) apart to receive the cotter pins. Two of these pieces are used to hold a finger piece which supports the bowl. In this way the bowl-hanger may be adjusted to take bolts from 10 in. up to 20 in. (25 to 51 cm.) in diameter.

Starting with bowl frosting to prevent glare from the exposed filament of high candlepower lamps, there has been a steady development[244] in this protective idea through various stages, from silvering, to an opaque metal cap supported by a wire clip around the neck of the bulb, then to a glass diffusing cap similarly supported, up to a bowl of diffusing glassware which encloses more than half the filament and may be used alone or with an upper reflector supported from a socket. A number of reflector units to be supported by the lamp socket have been developed.[245]

[241] *Sci. Amer.*, Dec. 14, 1918, p. 484.
[242] *Elec. Rec*, Sept., 1918, p. 38
[243] *Elec. Rec.*, Nov. 1918, p. 28.
[244] *Elec. Rec.*, Nov., 1918, p. 29.
[245] *Elec. Merch.*, Jan., 1919, p. 42.

Special lamp cord has been designed[246] to meet the requirements for portable lamps employed for local lighting around railroad yards, in boilers, under locomotives, etc. A pull socket developed for use with high wattage lamps[247] has a quick make-and-break mechanism and a wide breaking distance. The lever which operates the mechanism rides around a fulcrum and can be pulled in any direction or straight out. Omitting the chain, the lever can be operated with a slight pressure of the thumb. The pull-chain switch[248] has been adapted to chandeliers by attaching it to the canopy, thus eliminating the necessity of a side-wall switch. A combination switch[249] has been brought out for control of headlights for locomotives. It is self-contained, and dust tight. In operating the switch, the handle goes from the "off" position to the "dim" light position and then into the "full." Thus the filament of the lamp is heated before subjection to the full current. A second "dim" position is used momentarily when passing another locomotive, and the switch turns automatically to "full" when the handle is released. The use of the tumbler-type of wall switches is said to be growing steadily. The Department of Gas and Electricity of Chicago has developed[250] a method for installing ornamental and outline lights on the mosaic tile fronts of theatres and other large buildings.

Manufacture.—It appears that fixture dealers are beginning to realize the advantages of standardization[251] and at least one fixture dealer has standardized a complete line of residential fixtures. The United States Fuel Administration,[252] in addition to recommending the discontinuance of inefficient lamps, called upon fixture manufacturers to so modify old designs of fixtures as to make them better suited for the higher efficiency lamps. In an editorial discussion of this question it was pointed out that fixture designers oftentimes need the help of illumination experts, and it was suggested that a committee of this Society might be appointed to co-operate with the Fuel Administration and the manufacturers in giving general guidance to the latter on the im-

246 *Ry. Elec. Eng.*, Nov. 1918, p. 372.

247 *Elec. W'ld.*, Nov. 16, 1918, p. 903.

248 *Elec. Merch.*, Mar., 1919, p. 155.

249 *Elec. W'ld.*, July 10, 1919, p. 162.

250 *Elec. Rev.* (U. S.), Jan. 4, 1919, p. 41.

251 *Elec. Rec.*, Apr., 1919, p. 282.

252 *Elec. Rev.*, (U. S.), Nov. 9, 1918, pp. 731-732.

portant principles which should not be overlooked in the redesign and entirely new designing of fixtures. Representatives of leading fixture manufacturers[253] and makers of illuminating glassware at the Convention of the Lighting Fixture Dealers' Society of America in Pittsburgh, Feb. 10 and 11, organized two new trade associations, The National Council of Lighting Fixture Manufacturers and The Illuminating Glass Manufacturers' Association.

PHOTOMETRY.

Instruments.—The use of a cube instead of a sphere for integrating photometry introduces, in the case of a source with a non-uniform light distribution, errors of considerable magnitude. But it was found[254] at the National Physical Laboratory in England, in the course of an investigation of large carbon arcs, that this difficulty could be overcome if the comparison source had approximately the same distribution, and for this purpose a large metal filament lamp with a shade of hemispherical shape was used, as it was found to have a polar curve almost identical with that of the arcs studied, except at the central point. A difficulty encountered was the rapid aging of the inner surface of the cube due to the action of ultra-violet light in the arc. While the Ulbricht sphere has been used in the photometry of arc lamps and other large sources, it is difficult to get a sphere large enough to minimize the numerous sources of error. A new instrument[255] which has features similar to the integrating photometers of Mathews, Russel-Léonard, Blondel, Krüss, and others, is claimed to be particularly suitable for the measurement, by a single reading, of the mean spherical candlepower of large units. Plates of plaster of paris having a white mat surface are arranged around the circumference of a circle whose plane is perpendicular to the photometric axis and passes through the axis of the lamp. The plates are spaced at intervals corresponding to zones of equal area and make an angle of 45° with the plane of the circle. Direct light from the lamp is screened from the photometer. The latter thus receives the summation of the diffusely reflected light from the white surfaces, which is a measure of the average candlepower in one plane, or the mean spherical candlepower if the

[253] *Elec. Merch.*. Mar., 1919, p. 153.
[254] *Ill. Eng.* (Lond.), Dec., 1918, p. 272.
[255] *Elec.*, Feb., 28 1919, p. 255; Abs. from *Elek. Zeit.*, June 27, 1918, p. 253.

source is rotated. The instrument, like others of this type, has to be calibrated. Among the advantages claimed for it are practical independence of the size of the source; relatively small size of the plates (in a given case 2 cm. by 4 cm.); the plates do not have to be adjusted to suit the distance of the lamp from the photometer; and too much light does not reach the photometer. Measurements made with an actual instrument indicated that there is a minimum distance between the lamp and the photometer, within which shadows are encountered. In the descriptions available no reference is made to errors due to light from one plate striking another, or to the disadvantage, in the case of sources which cannot be rotated, of having to take measurements in a number of vertical planes.

Methods.—The idea of using the ability to read type as a measure of candlepower has been revived[256] in a method which utilizes the principle that up to a certain point the distance at which letters of a certain size can be read increases rapidly with the intensity of the light, but when the intensity exceeds a certain value the increase in distance is small. The procedure is to note the distance at which a certain type can be seen with the unaided eye, and then the corresponding distance when a pair of smoked glasses is placed in front of the eyes. The ratio of the two distances is taken as a measure of the intensity, the glasses having been calibrated. The British Illuminating Engineering Society was asked in 1916 by the Ministry of Munitions of Great Britain to devise[257] a method and apparatus for comparing the illumination values of flash lights, flares, star-shell compounds, and similarly rapidly-burning compositions. A portable photometer was designed with which the variations in the light could be followed and measured at any instant. It consisted of a tube 63.5 cm. long and 7.5 cm. in diameter, with its interior whitened and illuminated by a small electric lamp placed at one end. A slot 5 cm. wide extended nearly the whole length of the tube and was covered with a strip of thin metal having a series of perforations in the form of letters. This strip was painted white and received the illumination to be measured. The whole formed a modification of the old grid photometer. Reference to the ex-

[256] *Il. Eng.* (Lond.), Sept., 1918, p. 211.
[257] *Il. Eng.* (Lond.), Nov., 1918, p. 253.

perimental results will be found under the heading "Illuminating Engineering."

Spectrophotometry.—An arrangement[258] for using photoelectric cells in connection with spectrophotometry has been devised and used especially for routine testing of spectral transmission. A null method involving the use of two cells forms the principal feature, and tests of the accuracy have shown that between wavelengths 0.41μ and 0.55μ inclusive the uncertainty in measuring transmissions lying between 0.00 and 1.00 is not greater than 1 per cent.

Standards.—A modification[259] of the well known proposal to use the radiation from a "black body" as the standard of light consists in using such a body at various temperatures corresponding in color to the sources being measured and a definite area which would be different depending on the candlepower desired. As a means of controlling the temperature it is suggested that the photo-electric cell and a null method be employed. Calculations indicate that the requirements for satisfactory operation border on the unattainable.

PHYSICS.

A new theory of matter attributes all chemical changes to the action of light.[260]

Light Sources.—An investigation has been made[261] of the influence of different factors upon the emission of light by gases and gas mixtures due to electric discharges. Nitrogen, argon, neon, and helium were used. In all cases the intensity of the spectral lines or bands was found to be proportional to the supplied energy and with decrease of pressure the maximum was shifted towards the ultra-violet. With argon, the red and blue spectra exhibited totally different behavior with respect to the supplied energy.

Properties.—The method of measuring the temperature of a flame by measuring the temperature which is assumed by a body introduced into the flame involves two prominent sources of error, the loss of heat by the body through conduction and radia-

258 *Jour. Optical Soc. of Amer.*, Jan.-Mar., 1919, p. 23.
259 *Ill. Eng.* (Lond.), Aug., 1918, p. 195.
260 *Annales de Physique*, Jan.-Feb., 1919.
261 *Sci. Amer. Supp.*, Nov. 16, 1918, p. 319.

tion, and the cooling effect on the flame of introducing a foreign element. A means of eliminating the first difficulty[262] is to electrically heat the body, and a criterion of the completeness of the compensation has been suggested. For flames containing incandescent carbon particles, carbon will be deposited if the foreign agent, generally a wire, is at a temperature lower than the flame. Using this method, the temperature of the Hefner standard candle has been redetermined and found to be 1,705° K (Centigrade + 273°). Additional data have been reported[263] on the thermo-electric properties of tungsten.

In the 1917 and 1918 Progress Reports, reference was made to investigations of the properties of pigments. Another study[264] of the optical properties of commercial pigments should be referred to. It is pointed out that the hue, purity and brightness of light diffused by a pigment or paint depend upon the refractive index, absorption, size, shape and texture of the grains, and further upon the index, color and continuity of the vehicle and the distribution of the grains in the vehicle. Methods for determining the optical constants are given.

Luminescence.—A new theory[265] with regard to the nature of fluorescence in relation to the breaking down and building up of molecules has been proposed as the result of an extended investigation of the fluorescence of fluids. Solutions, ultra-microscopic in thickness, were employed, and the results indicated that the emission of fluorescence involves the destruction of the fluorescent body. In fact, it is suggested that perhaps the molecule is fluorescent only at the very instant of its destruction. An interesting point brought out by the experiments was that temperature and viscosity appear to exert no influence upon fluorescent powers. Additional study of the subject[266] of fluorescence and phosphorescence has been reported from abroad. Recent experiments on crystalloluminescence[267] of sodium chloride tend to substantiate the view that the phenomenon is a purely chemical one resulting from the rapid union of the ions with the formation of the non-dissociated salt. The color was found to be bluish white

262 *Gas Jour.*, Sept. 24, 1918, p. 576.
263 *Comptes Rendus*, Sept. 30, 1918, p. 485.
264 *Sci. Abstr.* "A" Aug. 31, 1918, p. 320.
265 *Sci. Amer. Supp.*, Mar. 15, 1919, p. 162.
266 *Ill. Eng.* (Lond.), Aug., 1918, p. 197.
267 *Jour. of Phys. Chem.*, Oct. 1918, p. 480, and Nov., 1918, p. 57[illegible]

and to contain no red, yellow, or green. Studies were also made and results obtained with potassium chloride, bromide and iodide, but not with sodium bromide and iodide. It was found that the maximum intensity of crystalloluminescence resulted under certain conditions which favor the accumulation throughout the solution of the largest possible concentration of ions in excess of the equilibrium concentration. Experiments on triboluminescence indicated that it, like crystalloluminescence, is caused by chemical action. In the case of substances which show both, like arsenic trioxide and potassium sulphate, the chemical reaction and hence the color of the luminescence are identical. The crystalloluminescence of inorganic substances is due to the rapid reformation of molecules broken up by the process of electrolytic dissociation; triboluminescence of the same substance is due to the rapid reformation of molecules broken up by violent disruption of crystals. All crystalloluminescent substances show the property of triboluminescence, but the reverse is not true.

Photo-Electric and Selenium Cells.—Further work has been done[268] on the color sensibility of photo-electric cells. Eight cells, using various alkali hydrides as the sensitive material, were studied. The maximum sensitiveness found was of the order of 10^{-7} amperes per erg, using rather low potential differences. Three potassium-hydrogen cells had about the same sensitiveness at the same wave-length. The maximum was shifted toward longer wave-lengths with respect to the maximum of pure potassium cells. Those using hydrogen compounds of sodium and rubidium showed a shift of the maximum toward shorter wave-lengths, as compared to those using the metals themselves. In general, cells having the compounds with hydrogen appeared to be more sensitive than those made up with the pure metals. A very peculiar action of light has been discovered[269] in connection with a study of its effect on photo-electric cells of the type consisting of a plate or wire of copper coated with a filament of oxide and immersed in a solution of copper salt together with another electrode of clean copper. By alternately illuminating one electrode, the other being dark, a steady alternating current was developed without apparent disintegration of the electrodes.

[268] *Astrophys. Jour.*, June, 1919, p. 303.
[269] *Elec.*, July 26, 1918, p. 265.

Changes in the construction of selenium cells are said to have resulted in considerable advances[270] in overcoming inertia, fatigue, dependence on previous treatment, and variations in the dark resistances. Tests made to show the suitability of the cells for use in measuring light intensities showed in some cases a constant resistance after 45 seconds exposure. The test specimens were subjected to alternate periods of light and darkness. With increasing lengths of dark periods the difference between the resistance at the successive light periods diminished, and at periods of 8 minutes of darkness the resistance during the light periods became constant, the illumination being 47.4 lux. The length of the dark periods producing the constant resistance under successive light stimuli was found to vary with the intensity of the illumination. Experiments on the effects of gases and metallic vapors on the electric properties exhibited by selenium crystals of the hexagonal system indicate that[271] these properties may be altered by subjecting the crystals to the action of different gases. The effect of the gas seems to be more detrimental the higher its atomic weight. The effect of metallic vapors is to form a conducting film on the surface that may under certain conditions give an apparent light-negative reaction to crystals that are normally light-positive.

Constants.—A new equation for the spectral energy distribution of radiation from an ideal radiator, black body, takes the following form;[272]

$$E_\lambda = D_1 T^5 e^{-D_2[\Lambda^{-1/3} - (\lambda T)^{-1/3}]^2}$$

where $E\lambda$ = energy of wave-length λ in the same sense as in the Wien and Planck equations

D_1 and D_2 are constants

T = absolute temperature in degrees Kelvin

Λ = Wien displacement constant in micron degrees

λ = wave-lengths in microns

Final values of the constants have not yet been published but $\Lambda = 2940$, $D_2 = 4640$ [micron deg.]$^{\frac{1}{3}}$ have been found to[273]

[27?] *Elec. Wld.*, June 28, 1919, p. 1401.

[271] *Phys. Rev.*, Oct. 18, 1918, p. 325.

[272] *Jour. Opt. Soc. of Amer.*, Jan.-Mar., 1919, p. [illegible].

[273] *Phys. Rev.*, Aug., 1919, p. 191.

satisfy data already obtained. Another determination of the brightness of a black body at the melting point of gold (1,336°K)[274] gave 0.119 Hefner candles per square centimeter. The mechanical equivalent of light was calculated to be 51.7 Hefner candles per watt.

LEGISLATION.

Interest in legislation to enforce proper lighting in the industries is growing and it would seem that a large amount of educational work has been accomplished by the Society through its committees and propaganda. The tendency for each state to have a different code has been criticized[275] as departing from the modern trend toward standardization. In France a movement[276] is on foot to bring about better illumination in factories, workshops, schools, etc., and in Great Britain the war has stimulated the work which our English sister society has been pushing so vigorously.

Codes.—The revision of the industrial lighting code[277] of Wisconsin having been completed, it was adopted May 20, 1918, to take effect July 1, 1918. The new code differs from that of 1913 and some other codes in that it defines terms used; definitely specifies the intensity of illumination to be provided for the different classes of work; and provides for adequate, properly applied natural illumination. In addition, shading of lamps is made mandatory in certain conditions under which bare lamps would cause glare; the distribution of light on the work must be reasonably uniform; emergency lighting is required; pilot or night lights and easily accessible control are specified, and maintenance made mandatory. The illumination intensities at the work are the same as those recommended by our Committee on Lighting Legislation with the addition of values for toilets and wash-rooms. It is recognized that the "glare" rule adopted may have to be changed after being tried out. Light sources of lower brightness than 75 candles per square inch may be used exposed, but conditions of individual installations may require shading even with such sources. Progress is being made in formulating industrial

[274] *Proc. K. Akad. Amsterdam*, 1918, p. 1036.
[275] *Elec. Wld.*, Apr. 26, 1919, p. 858.
[276] *Elec. Rev.* (U. S.), Dec. 28, 1918, p. 1006.
[277] *Elec. Wld.*, Aug. 31, 1918, p. 391.

lighting rules[278] for incorporation in the "Ohio Industrial Lighting Code." Further reference to this Code will be found under the heading "Interior Illumination." A bill[279] establishing an industrial lighting code has been passed by the Oregon legislature. It does not include definite quantity values but gives the state commission power to fix general intensity and conditions of glare, distribution and emergency lighting.

For the special guidance of the factory inspectors of the Massachusetts Board of Labor and Industries, an instructional conference[280] was held in Boston under the auspices of the Divisional Committee on Lighting of the Advisory Commission, Council of National Defence. The program included six lectures covering principles of lighting, hygienic aspects, measurement, and specific cases. The Board has employed an illuminating engineer to formulate an industrial code[281] for the state.

The New York Industrial Commission promulgated[282] data early in the year on the minimum intensities of illumination required for a large number of specific cases with the provision that they would be mandatory on July 1st unless previous experience showed changes to be desirable. Twenty-five per cent. of the initial illumination must be allowed as a factor of safety covering deterioration of lamps and fixtures. Up to March 1, 1919, 3,290 orders[283] for changes in lighting had been given and 1,569 compliances secured.

PHYSIOLOGY.

Apparatus.—The fact, that if a haze in the atmosphere is bright enough it will shut out from view objects lying back of it, has been made the basis of an instrument[284] called a visibility meter which was used during the war to study the production and effect of camouflage for use in protecting ships from submarine attacks. The instrument is now being used to determine schemes of painting which will make a ship most visible and her course most evident. There are certain vocations in which speed and accuracy of adjustment of the eye for clear seeing at different

278 *Elec. Wld.*, Apr. 12, 1919, p. 750.
279 *A. I. E. E.* (Trans.), April 1919, p. 614.
280 *Elec. Wld.*, Nov. 9, 1918, p. 904.
281 *Elec. Wld.*, Apr. 26, 1919, p. 858.
282 *Elec. Wld.*, Apr. 5, 1919, p. 670.
283 *Elec. Wld.*, Apr. 19, 1919, p. 806.
284 *Sci. Amer.*, May 3, 1919, p. 457.

distances is of importance. Aviation might be cited as an illustration. Apparatus for the study of these ocular functions has been devised and a number of experiments[285] have been made. Using eighteen observers, the time required to pass from near seeing (object distant 18 cm.) to far seeing (object distant 6 m.) varied between 0.5 and 1.16 seconds, a range of 132 per cent. from far to near, the range was from 0.39 to 0.82 seconds, or 110 per cent. and from near to far, and back to near, from 0.96 to 1.76 seconds, or a range of 83 per cent. Eighty-three and one-third per cent. of these observers required longer to change from near to far than from far to near. It is suggested that if speed of reading as well as accuracy were made a part of the conventional acuity test, a greater sensitivity enabling a much finer grading of the resolving power of the eye would result.

A novel use[286] of radio-active preparations, such as those employed to make luminous watch dials, is to be found in an instrument which was devised to test minimum light sense and retinal adaptation. A series of prepared buttons was mounted around a disk, and picked so that they had the same luminous intensity as determined by photographic means. Different layers of white celluloid were used to cover the disks so that the intensity varied from a minimum to the full value. The disk was observed through an eye piece, and the results to a large degree confirmed the work of others. The Council of British Ophthalmologists has issued a report[287] with recommendations, on the illumination of Snellen's types used in testing the vision of candidates for public service. The minimum illumination permissible is given as 3 footcandles and may be as high as 10. The illumination should be as uniform as possible and artificial illumination should be used in preference to daylight. The testing room should be moderately illuminated, and extreme contrast between the illumination test cards should be avoided.

Retinal Characteristics.—Experiments have been made[288] which seem to show that equal amounts of light may determine widely different quantitative impressions on the retina according to their way of striking it, such impressions being much greater

[285] *Amer. Jour. of Psych.*, Jan., 1919, p. 40.
[286] *Amer. Jour. of Ophthal.*, Jan., 1919, p. 13.
[287] *Ill. Eng.* (Lond.), Jan., 1919, p. 5.
[288] *Sci. Amer.*, Sept. 28, 1918, p. 255.

when the light gradually increases to a maximum than when it suddenly starts with its maximum intensity. The name "retinian inertia" has been proposed for this phenomenon. It does not seem to be the same for various wave-lengths. For a long time it has been known that electrical changes go on in the retina when exposed to light. Additional study[289] has been made of the effects of various colors upon this retinal response, for the purpose of determining the directions of the electromotive forces, *i. e.*, whether the current is from the nerve to the retina, or *vice versa;* whether or not excessive action of a given monochromatic radiation will promote the subsequent action of its complementary; and the possible bearing of the experimental results upon theories of color vision. A determination[290] has been made of the chromatic thresholds of sensation from the center to the periphery of the retina. It was thought that knowledge of the sensitivity gradient for this region of the retina for the four colors, red, green, blue, and yellow, would be of interest in connection with certain points of color theory. In tests on the persistence of vision[291] of different parts of the retina, it was found that this phenomenon is a maximum at the center of the eye and diminishes from this point to the periphery. In an attempt to discover if there is any correlation[292] between sensitiveness of the visual tracts, insofar as that is measured by acuity in brightness discrimination and effectiveness in visualization, the following conclusions were drawn from tests on seventy-five students:

> The correlation for visualization and brightness discrimination is slightly positive. The evidence seems to be that individual differences in visualization cannot be explained as due to differences in visual sensitivity.
>
> No correlation was found between brightness discrimination and either memory for letters and digits, or speed in multiplying.

Experiments to determine,[293] if possible, the number of fundamental color sensations and the precise light-waves by which they are excited have been carried out using a method depending on the persistence of vision. The results were interpreted as supporting the theory of three primary sensations, red, green and violet,

[289] *Amer. Jour. of Physiol.*, Feb. 1, 1919, p. [illegible]

[290] *Psych. Rev.*, Jan., [illegible], p. [illegible]

[291] *Comptes Rendus*, June 16, [illegible], p. [illegible]

[292] *Psych. Rev.*, Jan., [illegible], p. [illegible]

[293] *Phil. Mag.*, July, [illegible], p. [illegible]

and two compound sensations, yellow and blue. Additional work has also been done on the persistence of vision of colors of varying intensity using a similar method.

As a result of tests[294] on the visual factors involved in continuous tenancy of gas masks, reported by the Psychology Committee of the National Research Council, it was found that "the most consistent and largest effect of gas-mask tenancy was decrease of visual acuity, an average of 20 per cent." A Research Board has been appointed[295] in England to deal with industrial fatigue. The influence of inadequate lighting will be an important phase of the work to be undertaken.

The germicidal action[296] of ultra-violet radiation has been tested by exposing to it, in a spectograph, a plate painted with living bacterial emulsion. After incubation, it was found that the germicidal effect ended abruptly at 0.244μ. The result was verified by the detection of a selective absorption of the bacterial emulsion in the same region.

The Public Health Service of the Government has published a bulletin[297] on color blindness. Results of tests on one thousand persons are given, the examinations being part of a series of other studies on the effect of illumination on vision, conducted as a part of an illumination survey of the Federal Department buildings in Washington. Among the conclusions arrived at are the following:

> Color blindness is best detected by testing with colored lights of known spectral composition. In every day life among healthy individuals in America, color blindness (excluding the pentachromic) occurs in about 8.6 per cent. of men and 2.2 per cent. of women. Color blindness of a degree dangerous in occupations requiring recognition of colored signal lights occurs in about 3.1 per cent. of men and about 0.7 per cent. of women.

ILLUMINATING ENGINEERING.

Daylight Saving.—Credit for the modern conception of the "Daylight Saving" idea is given to Wm. Willett, an English architect who began his campaign in 1907.[298] The objections to the

[294] *Psych. Rev.*, Mar., 1919, p. 122.
[295] *Ill. Eng.* (Lond.), Nov., 1918, p. 248.
[296] *Archives Rad. and Elect.*, Aug., 1918, p. 85.
[297] *Public Health Bulletin No. 92*, *U. S. Public Health Service.*
[298] *Gas Age*, Nov. 15, 1918, p. 458.

daylight saving[299] as voiced by the farmer are that much of the field work, such as weeding and hay cutting, cannot be done until the dew is off the ground; that the afternoon is better for work in the fields and hired help has insisted on leaving according to the clock rather than the sun, thereby cutting off an hour of the day's labor; and that it is difficult to drive in the cows when the sun is high in the sky. Pursuant to the Congressional Daylight Saving Act, which required the Interstate Commerce Commission to define the limits of standard time zones, an order was issued by the Commission effective January 1, 1919[300] fixing and unifying time zones in the United States.

In sixteen of the larger hotels in the White Mountain district[301] there was a difference in electric power consumption for the years 1916 and 1918 of about 12,000 kw.-hrs. which was attributed to the effect of daylight saving. At Aurora, Illinois,[302] the average lighting customer's bill was 26 cents per month less in the summer of 1918 than in 1917, an effect also attributed to this cause. In France[303] it was calculated that the cash saving for this year would be roughly $20,000,000 as compared with about $15,000,000 saved last year. Records of a New England Company[304] show that instead of an average annual increase in business of 16 per cent., there was a decrease of 14 per cent. in the small towns where the load is chiefly made up of residential and street lighting. In Boston, the change[305] in load at the central station before and after the change in time in the fall amounted to 15,000 kw., part of the increase being due to the street lighting service. A decrease in coal consumption of 4420 long tons[306] during the year was attributed to the extra hour of daylight. In Iowa[307] the plan was not considered satisfactory by central station men, and a similar view was held in Illinois.[308] It was estimated[309] that the operation of the law during the seven months of 1918 was responsible for a saving in the country as a whole of from 1,000,000 to 1,500,000 tons of coal.

299 *Sci. Amer.*, Mar. 8, 1919, p. 220.
300 *Gas Age*, Dec. 2, 1918, p. 492.
301 *Elec. W'ld*, June 22, [illegible], p. 1339.
302 *Elec. W'ld*, Jan. 18, 1919, p. 135.
303 *Gas Jour.*, Feb. 18, [illegible], p. [illegible].
304 *Elec. W'ld*, Nov. 16, 1918, p. [illegible].
305 *Elec. W'ld*, Nov. 23, 1918, p. [illegible].
306 *Elec. Rev.* (U. S.), July 19, 1919, p. 105.
307 *Elec. W'ld*, Dec. 21, 1918, p. 1179.
308 *Elec. W'ld*, Dec. 28, 1918, p. 1229.
309 *Gas Age*, Oct. 15, 1918, p. 370.

In June[310] both Houses of Congress passed measures repealing the Daylight Saving Law, to take effect in October when the return to normal time would naturally be made, but the veto of the President[311] exercised twice on the subject made it necessary to take additional action and the repeal was finally passed on Aug. 20, 1919. An effort[312] made last year to extend the Daylight Saving Act throughout the winter failed to produce any result. The Canadian Parliament,[313] after considering the matter, decided not to enact a law of this type during the past year. On the other hand, during the annual meeting of the Indiana Electric Light Association[314] a resolution was passed urging the continuance of the plan in this country.

Light Sources.—Experiments on the illuminating power of flares, flashlights, star shells, etc., were carried on in England[315] during the war. The tests on flares showed several different time-characteristics. Some start with a brilliant burst, others show a distinctly rhythmical effect. In the case of star shells, tests were made on samples all of the same length and diameter, but containing progressively different quantities of one of the constituents. The relation between diameter and illuminating value was also studied. It was found that the efficiency rose rapidly as the diameter was increased. The results of the experiments made it possible to calculate the height at which a given flare should be burned to give a certain illumination on the ground. Reference should be made to the tests on flares reported through our Society and given in the TRANSACTIONS.

As a possible substitute for radium salts[316] "mesothorium" has been proposed. The objection to the substance lies in its relatively short useful life, about five or six years, and it therefore seems best adapted to replace radium in luminous paint for those objects only which are required to have quite a short life, and are not preserved afterwards. Mesothorium is found in monazite and other thorium minerals. The work on the brightness of radio-active self-luminous materials referred to in the 1917 Prog-

[310] *Elec. Wld.*, June 28, 1919, p. 1409.
[311] *Cleveland Plain Dealer*, Aug. 21, 1919, p. 15.
[312] *Jour. of Elec.*, Oct. 1, 1918, p. 302.
[313] *Moving Picture World*, March 29, 1919, p. 1779,
[314] *Elec. Wld.*, Sept. 7, 1918, p. 454.
[315] *Ill. Eng.* (Lond.), Nov., 1918, p. 258.
[316] *Elec.*, Oct. 25, 1918, p. 528.

ress Report has been continued in England and new data have been published.[317] The method used consisted in viewing the luminous sample through a very small slit in a white surface illuminated by an auxiliary lamp screened by a suitable green filter. The rate of decay in brightness of samples containing varying percentages of radium bromide was found to be similar to that of other observers, a short initial increase being followed by a steady, but gradually diminishing fall. The maximum brightness values for freshly prepared material were found to be roughly proportional to the radium content. From these tests the conclusion was drawn that if such materials are to be in use for long periods, there is no advantage in using a compound of greater strength than 0.2 mg/mg while 0.1 mg/mg (roughly equivalent to 0.4 mg/mg compound applied in the form of paint) would be better in many cases. The effect of depth of material was also studied and a thickness of 0.3 mm. appeared to be sufficient.

Among the phenomena associated with fireflies[318] is that of concerted or synchronous flashing by large numbers. Additional evidence to this effect has been reported by an observer in the Philippine Islands, and by another[319] at Valcour Island in Lake Champlain. A study has been made[320] of what is called a "fire-fly squid" found in the Japan Sea and which belongs to the genus of luminous cephalopods. It has three kinds of luminous organs. The animal cannot live in the upper layer of sea water and this is attributed to the low osmotic pressure. The phenomenon of luminescence in this animal is of the intra-cellular type and is due to an oxidation. Direct sunlight was found to have no effect on the luminescence.

Astronomy.—From the known data on brilliancy and parallax the light of a variety of stars has been compared[321] with that from the sun, assuming the stars to be at the same distance from the earth as the sun. The results are indicated in the following table:

317 *El. Eng.* (Lond.), Nov., 1928, p. 290.
318 *Science*, Dec. 6, 1928, p. 573.
319 *Science*, Oct. 26, 1928, p. 418.
320 *Amer. Jour. of Physiol.*, Jan. 1, 1929, p. [illegible]
321 *Sci. Amer. Supp.*, June 21, 1920, p. 400.

Name	Magnitude	Parallax	Light compared to sun
Sirius	—1.7	0.37	36
Vega	0.1	0.08	145
Alpha centauri	0.2	0.75	1.5
Capella	0.2	0.08	133
Arcturus	0.3	0.03	832
Procyon	0.5	0.33	5.8
Altair	0.8	0.23	9.1
Betelgeux	1.0	0.02	1000
Aldebaran	1.1	0.11	30
Pollux	1.3	0.06	83
Fomalhaut	1.3	0.13	17
Regulus	1.4	0.02	692

Data have been published[322] on the relative brightness of the parts of the starry sky as compared with the brightness of a part containing a star of the fifth magnitude. It was found that the illumination per degree square of the region containing the Milky Way is 1.7 times that of the regions outside it.

Considering that diffraction alone is insufficient to account for the morning and evening sky colors, a foreign scientist has put forward[323] the theory that the production of the effects depends upon diffuse reflection of light from a layer of discontinuity such as the stratasphere. Laboratory experiments have been devised[324] to show that there is a scattering of light by dust-free air, a fact which will almost completely account for the luminosity and blue color of the sky on very clear days and at considerable altitudes above the sea level without postulating suspended particles of foreign matter. Examination of gases other than air show that hydrogen gives much less scattering than air, oxygen about the same, carbon dioxide decidedly more, but the scattered light in all cases was the blue of the sky. All the results were in qualitative agreement with the theory which attributes this blue color of the sky to the scattering of light by the molecules of air and not by dust particles in it. Using aeroplanes and a modified Marten's photometer, an elaborate study of relative sea, land and sky brightnesses has been made,[325] as well as a determination of reflection factors for various different kinds of earth areas. On a clear, cloudless day in June with the maximum altitude of the sun as 74°, the illumination on a horizontal surface due to direct sunlight throughout a period from 6 a. m. to 6 p. m. was found

[322] *Comptes Rendus*, June 10, 1918, p. 943.
[323] *Sci. Amer. Supp.*, Nov. 30, 1918, p. 341.
[324] *Proc. Royal Soc.*, June, 1918, p. 453.
[325] *Astro. Jour.*, Mar. 1, 1919, p. 108.

to approximate a sine curve, while the illumination due to scattered light was nearly constant and the ratio of skylight illumination to total illumination at noon was 0.1. The brightness in terms of that of a white diffusely reflecting or transmitting surface receiving the same illumination or apparent reflection factors of fields was found to be on the average 6.8; of barren land, 13.0; of woods, 4.3; of inland water, 6.8; dense clouds, 55 to 78 for upper sides; deep ocean water, 50 miles from shore, 3.5; upper surface of various kinds of clouds from 36 to 78. The actual brightness of the sky was found to vary from 0.5 to 2 lamberts. Sky-brightness measurements were made at altitudes ranging from the earth's surface to 20,000 feet.

Using a pyranometer suspended below the basket of an army observation balloon,[326] the reflecting power of a level cloud surface practically filling a hemisphere of solid angle has been obtained. The mean value was 78 per cent. No change of total reflection depending upon solar zenith distance was apparent within a range of zenith distance from 33° to 69°. A value of 43 per cent. for the albedo of the earth was obtained by revision of the earlier value of Abbot and Fowle.

It has been decided by the British Admiralty[327] that beginning with the Almanac for 1925, the day shall begin at midnight so as to make the astronomical agree with the civil day. This change was decided upon after consultation with the Royal Astronomical Society, and chiefly in the interests of seamen who will find it more convenient to have the same time system in use for purposes of navigation and for ordinary life on board ship. The darkness of the Arctic night[328] and the gloom of the old blubber lamp were dispelled for MacMillan and his party in Crocker Land by the use of a portable electric generator set which furnished current for lamps inside the camps and for a headlight outside the front door.

Optical Glass.—At the beginning of the war,[329] but little optical glass was being produced in the United States, but the enlarged need and the cutting off of outside supplies has brought together the manufacturers on the one hand, and the technical and scien-

326 *Monthly Weather Review*, Mar., 1919, p. 154.
327 *Nature*, Apr. 10, 1919, p. 115.
328 *Elec. Rev.* (Lond.), Jan. 17, 1919, p. 70.
329 *Chem. & Metall. Eng.*, Sept. 27, 1918, p. 469.

tific organizations on the other hand, and there has resulted a satisfactory product. The essentials of optical glass manufacturing have been mastered and about seven types are now being made commercially.

A number of investigations[330] have been made in the past on the transmission of various colored glasses used in commerce to separate different parts of the visible and ultra-violet spectrum. Data have now been published showing the transmission for infra-red. From this information it is possible to pick out glasses which when combined will transmit narrow spectral bands of high intensity at the following points in the spectrum; 0.38μ; 0.5μ; 0.55μ; 0.7μ; 1.0μ; 2.2μ. Additional data have been published[331] on the transmission in the ultra-violet of a number of glasses.

As in the case of the reflection factor,[332] the determination of the transmission factor of glassware is not a simple problem. An integrating method has been studied and under certain conditions appears to give satisfactory results. Transmission factors for several representative, slightly diffusive glasses, such as those used for skylights, office doors, etc., have been obtained for two kinds of illumination, first, a narrow beam of light in a direction perpendicular to the surface of the specimen, and second, uniformly diffused light reaching the specimen from all directions above its plane. In general the transmission factor is less for the second case (diffused illumination) than for the first. Again for glass having a rough and a smooth side, the transmission was found to be considerably greater when the rough surface faced the light source. This phenomenon is very apparent visually in the case of ribbed glass, but has been found to exist even for so-called "frosted" or etched glass. Similar work has been done on wire glass.[333] The effect of temperature on the transmission of colored[334] glasses has been measured for a number of typical cases and it was found that in going from a temperature of 30° to 350°C, the transmission factor was decreased in every case but that of a light blue glass, by amounts varying from 7 to 58 per cent. The transmission factor of the light blue (a cobalt

[330] *Bul. Bur. of Stds.*, Vol. 14, 1918, p. 653.

[331] *Jour. of Opt. Soc. of Amer.*, Jan.-Mar., 1919, p. 26.

[332] *Jour. of Frank. Inst.*, Nov., 1918, p. 529.

[333] *Abst. Bul. Eastman Kodak Co.*, June, 1919, p. 120.

[334] *Jour. of Frank. Inst.*, Feb., 1919, p. 225.

glass) increased by 8 per cent. The curves obtained by plotting temperature and transmission factors were approximately straight lines.

Researches in the use of selenium[335] as a decolorizer in glass manufacture showed that glasses decolorized by this element are more brilliant than those in which manganese or nickel oxide are used. The action of the selenium is attributed to the formation of minute particles which give a red color neutralizing the faint green caused by the presence of iron. It is pointed out, however, that for lead glasses selenium should not be used and that prolonged exposure to the bright sunlight of glasses decolorized by selenium produces a brownish tinge. An excellent example[336] of the constructive use of a destructive process is to be found in the proposal to utilize the action of ultra-violet light which causes the discolorizing of lamp globes, to produce new color effects in glasses and analogous substances such as porcelain, quartz and some of the precious and semi-precious stones. Experiments along this line indicate no physical change other than that of color. White optical glass exposed to radiation from an ordinary quartz mercury lamp was found to have the same characteristics as those shown by clear glass exposed to sunlight for many years. It has been reported[337] that the Medical Research Board of the Division of Aeronautics has found a substitute for glass for aviators goggles. The substance is described as hard, non-inflammable, and to form a practically non-shattering lens.

Action of Light.—Tests have shown[338] that white paint made with poppy-seed oil has less tendency to turn yellow than when made of linseed oil. An investigation of the causes of the yellowing of paper[339] has confirmed previous work showing that it is due to the formation of resin-iron compounds and that where it is necessary that a paper retain its original color, the resin sizing should be reduced to as small an amount as possible, and an iron-free aluminum sulphate should always be used as a precipitant. Animal sizing should be omitted or kept as low as possible. A comparison of the effect[340] produced on silks, plas-

335 *Elec.*, Aug. 23, 1918, p. 348

336 *Ill. Eng.* (Lond.), Oct., 1918, p. 272

337 *Sci. Amer.*, Dec. 7, 1918, p. [illegible]

338 *Sci. Amer. Supp.*, Feb. 8, 1919, p. 91

339 *Sci. Amer. Supp.*, Apr. 5, 1919, p. 223

340 *Ann. Chimie Analytique*, May, 1919, p. 142

ters, paints, etc., by ultra-violet light from the quartz mercury arc showed that in two to four hours exposure the quantitative action was the same as that produced by exposure to the sun for thirty days. The character of the effects produced was the same. A method has been worked out[341] for obtaining a definite measure and, thereby, standardizing the quantity of actinic light used in dye-fading tests. It is based upon the measurement of the quantity of actinic light required to produce a visible change of the tone or depth of the test sample by noting the number of consecutively exposed standard strips of a quickly fading color, which are completely bleached under the same conditions. Eosine is suggested as a dye-stuff fulfilling the conditions as a dye standard as it quickly fades to clear white.

Photography.—The ordinary silver-bromide photographic plate[342] has its maximum sensibility for light in the blue region of the spectrum. The sensibility for the various parts of the spectrum can be changed as is well known by treatment of the emulsion or by bathing the finished plate in solutions of the proper color. Eosine, erythrosine, cyanine, etc., are used for this purpose. The distribution curve of an eosine-dipped plate shows two maxima. By adding the right amount of bichromate of calcium, an investigator claims to have altered the curve so that it fits very closely the visibility curve of the average human eye. Successful results[343] in submarine photography in color have been obtained. It has been found necessary to use special color screens cutting off more of the rays of shorter wave-length than those used for ordinary color photography in the air. In a study of Hawaiian fishes using color submarine cameras, twenty-seven species representing twenty-two general and nine families were found which show a marked capacity for changing their color with change of surroundings or activities.

Nomenclature.—A French electro-technical commission[344] has published a report containing recommendations for an electro-technical nomenclature with definitions. Among those interesting to the illuminating engineer are the "arc" which is defined as "phenomene lumineux————"; "bougie" which has the or-

[341] *Sci. Amer. Supp.*, Jan. 25, 1919, p. 57.

[342] *Rev. Gen. d'Elec.*, July 13, 1918, p. D12; *Elek. Tech. Zeit.*, Oct. 18, 1917, p. 506.

[343] *Sci. Amer.*, May 10, 1919, p. 481.

[344] *Bul. Soc. Fran. d'Elec.*, July-Oct. 1918, p. 289.

dinary definition as given by the International Conference at Paris in 1884; "carcel" defined as a "practical standard of luminous intensity;" "flux lumineux" which is defined as a vector quantity; "lumen" defined in practically the same terms as those used in this Society; "lux" the unit of illumination, illumination produced by a luminous flux of one lumen uniformly distributed over a surface equal to 1 sq. m." A proposed method[345] for naming glasses used for optical purposes consists in the use of two 3-figure numbers separated by an oblique stroke. The first number consists of the first three decimal figures in the value of the refractive index for the D line (N_D); the second figure is ten times the value of the function $V = (N_D - 1)(N_F - N_D)$ for the glass in question. Thus a glass whose value of N is 1.5072 and for which $N_\nu = 62.8$ is described as crown glass No. 507/628. In view of the recommendations of the last report of the Committee on Nomenclature and Standards as to the definition of the term "diffusing" applied to lighting, it is interesting to note that this subject has been considered by others. In an effort to find a precise method of defining the term one author[346] proposes "that the 'diffusion-co-efficient' of a surface should be defined as the ratio between the distributed flux of light and the light flux corresponding with ideal diffused distribution with the same maximum candlepower."

Societies.—Anticipating the approaching resumption of international[347] co-operation in the study of questions connected with the art and science of illumination, a meeting of the National Illumination Committee of Great Britain was held in May and vacancies in the executive committee were filled. The continuation of research work was considered. The fifth annual meeting of the German[348] I. E. S. was announced for Sept. 21, 1918, at Charlottenburg. The program called for a paper on "Means of Lighting in Relation to Architecture" and one on "Photometry of Searchlights." The gospel of good lighting practice preached by the Society for so many years and identified in the various codes is spreading all over the world. A paper entitled "Illumination and Some of its Fundamental Considera-

345 *Zeits. f. Instr.*, Apr. 1918, p. 49.
346 *Elek. und Masch.*, May 19, 1918, p. 225.
347 *Gas Jour.*, June 3, 1919, p. 633.
348 *Gas Jour.*, Oct. 15, 1918, p. 117.

tions" has been given before the South African[349] Institute of Electrical Engineers, and contains a table of standard illumination values which agrees with those at present recommended for standard practice in this country.

Books.

Works Lighting[350], D. H. Olgley, (London, Iliffe & Sons, Ltd.) pp. 135.

Gas and Gas Making, W. H. Y. Webber, (London, Sir Isaac Pitman and Sons, Ltd.) pp. 130.

The Results of Municipal Electric Lighting in Massachusetts, E. E. Lincoln, (New York, Houghton Mifflin Co.) pp. 484.

DISCUSSION.

C. O. Bond: While it probably has not been in print and therefore not seen by Mr. Cady, there has been a good steady growth in the gas lighting field with the semi-indirect bowls. They have been meeting with quite a popular demand so that while it is not new in the way of progress as a new lamp, it is rather novel in the demand that has been made for it, and the way it is being met. One of the larger factories told me they were having difficulty in keeping up with the supply.

In another place reference was made to the British Thermal Unit survey by the Indiana State Commission. No Ruling has been handed down by the Commission as yet, but the report of the Committee agreed upon 570 B. t. u.s which is a reduction from the 600 they had before. It shows a trend which is in progress all over the country, the result of which will be to eliminate largely the gases which are known as "wet" gases, vapors, and it is those vapors of condensible kind that have given a great deal of the pilot trouble in the past. The reduction, therefore, of B. t. u.s in general throughout the country will give a drier gas and ought to give a gas a great deal more satisfactory for lighting purposes than has been generally had in the past. Many people have become critics of gas lighting because of the poor service of the pilot lights. For that reason the resultant drier gas would be of a great deal of assistance in giving better service. As to the percentage of open flame lighting and its

349 *Elec. Wld.*, May 31, 1919, p. 1171.

350 *Ill. Eng.* (Lond.), Aug., 1918, p. 196.

causing a waste of two and one-half million tons of coal per year, I believe that is much exaggerated.

Figures which I did not have in possession until recently from one of our large cities show that while something like 38 or 40 per cent. of the customers along gas lines had in place open flame burners, and the supposition would be that that meant a very considerable consumption of gas through those burners, yet as a matter of fact, a very extensive survey had brought out the fact that only about 8 per cent. of the gas went through those burners. Now, if that is the case, in a town where there is a great percentage of open flame burners it would probably hold true—and their report showed it did—pretty generally for all classes of consumers. It was not confined simply to the houses where they thought the incandescent mantle too expensive, but went throughout all classes of consumers. If that is true I do not believe it would indicate two and one-half million tons of coal waste, from open flame burners.

C. M. Masson: I want to take this opportunity to speak about the Illumination Index as prepared by Committee on Progress, in the I. E. S. Transactions. This is very valuable to me, and constitutes a ready reference library on illuminating engineering subjects. I always enjoy reading over the Index and mark those subjects which appeal to me or which apply directly to my work, and later I shall make a classified card index of these subjects. The Index and Progress Report combined form a relilable and wonderful source of information at all times.

At the present time I am much interested in the subject of night illumination of golf links, and I wonder if the Committee on Progress or any member has any information or suggestion for me. Out in California we have a condition on certain of our golf courses where it would be too expensive or even impossible to keep the fairway green and still worse, the ground is a glary white almost like the sea sand. Under such condition, you will agree golfers would be inconvenienced and just a short experience of squinting would spoil the sport for the day.

I have in mind the golf course of one of California's fashionable country clubs. While its white surface would serve as an aid to the night illlumination, the problem is complicated by the rolling contour of the course.

G. H. STICKNEY: Answering Mr. Masson's inquiry, the lighting of golf courses for putting is not uncommon. The lighting of a regular golf course is likely to be expensive, both on account of the large area involved and the necessity of locating lamp supports where they will not obstruct play.

Years ago some of the middlewest cities, including Detroit, were lighted from lamps placed on slender towers, nearly 100 ft. high. It might be practicable, at the present time, to secure some of these towers, which have since been discarded, and mount properly selected units in such a manner as to distribute light over the more important parts of the course.

It would probably be practicable to furnish only a relatively low illumination, but if caddies were furnished with flashlights to illuminate the ball for each stroke and assist in finding it, it might be practicable to play on some types of courses.

L. C. PORTER: I was very much interested in the matter of invisible signals using the ultra-violet end of the spectrum. I think perhaps the Society would be interested in work which is being conducted at the Case Research Laboratory in Auburn, New York, where they are working on invisible signals using the other end of the spectrum. They have succeeded in transmitting speech perfectly clearly over what I might call an invisible beam of light for a distance of nine miles.

Another point which I wanted to touch on is at the end of the paper where mention is made of societies. Three years ago there was organized in this country the Society of Motion Picture Engineers. They have just finished a very successful convention in Pittsburgh. I would like to call to the attention of our Society this motion picture society as they are handling many subjects which are closely allied to our work. Take, for example, the projectionist who runs the moving picture machine. In the course of a year he handles something like a half a million dollars worth of equipment, film, apparatus and so forth, and has in his hands the comfort or discomfort of the eyes of perhaps a quarter of a million people (in a reasonably sized theatre). The Society of Motion Picture Engineers is studying the question of screen illumination, the design of theatres and also the application of light in the studios where people work under extremely

high intensities. I think that there could well be close co-operation between the two societies along these lines.

Louis Bell: I might add a word on invisible signaling with ultra-violet light as I was actively working on that for some little time during the war. The extraordinary feature of it is the effective signaling that has been done with very small apparatus. I found it was feasible with an apparatus no bigger than a pint dipper and a twelve watt lamp with dry battery cells to signal a couple of miles with ease. Thanks to the efficiency of the receiving apparatus, the readiness with which one could get a considerable distance with very small apparatus was rather remarkable.

Geo. A. Hoadley: In the report Mr. Cady spoke of an arc lamp being developed, I think the neon arc lamp. I want to learn the color of the light produced by that lamp.

F. E. Cady (in reply): As stated in the Report, the color of the light emitted by the neon gas is orange, but this may be rendered pinkish by the use of helium or by mercury vapor.

HOME LIGHTING—HOW TO MAKE IT COMFORTABLE AND EFFECTIVE.*

BY A. L. POWELL AND R. E. HARRINGTON.

The question of proper lighting in the home is one of fascination to everyone. All of us have rather fixed ideas as to what is best adapted to our own needs and to our own conception of the artistic.

Light is so universal in its application that everyone delights in experimenting with it and in determining what effects can be produced. This very familiarity often breeds contempt and we see on every hand examples of the misuse of modern light sources. Other forms of energy, such as electricity, are far less common and are treated with considerable more respect.

Artificial light is a wonderfully flexible medium at the disposal of the interior decorator, be he amateur or professional. No element of the decorative scheme offers as many possibilities or has as distinct a psychological effect. The possibilities are so great that a life-long search would not reveal all of them and the opportunities for the display of individual tastes are unlimited.

A properly lighted room at once gives the impression of a pleasing picture and a feeling of comfort. An interior inappropriately illuminated is always repelent although sometimes the casual observer does not realize that the light is at fault. No matter how skillfully a room may be planned as to harmony of fittings and balance of color, if the lighting equipment does not function properly, the decorator has failed to achieve success.

There are certain fundamentals which must be observed: First, the light must be comfortable. It must not be glaring or excessively brilliant. This produces eye strain and irritates the entire system. Extreme contrasts in light are objectionable. In other words, very bright areas adjacent to rather dark ones are not pleasing. Second, the fixture or glassware should be artistic and appropriate. Artificial lighting in the home should not be simply utilitarian in character. The fixture should not be crude and have for its sole excuse for existence the supplying of light.

* Paper presented before a meeting of the New York Section of the Illuminating Engineering Society, October 2, 1919, New York, N. Y.

It should be as much a part of the room decoration as the draperies, carpet, or furniture. Anything which is truly artistic is useful. As a rule the simpler designs are the more pleasing. In spite of this generally accepted law, we constantly see fixtures which serve no really useful purpose and which are most complicated and cumbersome in their make-up. Third, advantage should be taken of the adaptability of modern light sources to color modification and the light toned to suit the decorative scheme. Light is now produced so efficiently that color effects can be secured at a very reasonable cost.

There can be no hard and fast rules laid down as to what represents the best practise in lighting the various rooms in the home. There are many methods which might justly be applied to any one room. Even one's own ideas suffer modification from time to time. One arrangement and fitting of light sources may appear to be the best at the present time and yet in a few months, some quite different scheme may be substituted. Not only does this change of viewpoint occur but there is a great variation between individual preferences.

In view of the above, it is most essential that the home be so wired that flexibility of lighting is practical and can be obtained with minimum expense. A few dollars additional to the initial investment when a residence is being built will yield large returns in comfort and satisfaction. An attempt should not be made to minimize the initial wiring expense by sacrificing adaptability. This course of action usually proves to be false economy.

The lighting equipment itself need not be expensive, but on the other hand, one should not attempt to spend the absolute minimum when purchasing it, for the best in any class of merchandise is not cheap. One would hesitate to buy cheap, poorly designed furniture, but fixtures and lighting glassware are not so well understood or appreciated by the average purchaser and most anything goes.

The housewife would be perfectly willing to spend several dollars for some little vase or ornament which appealed to her fancy and which she thought would add to the appearance of the home. This is all right, but what a small effect such an object has on the general impression presented by the room.

On the other hand, a lighting unit by day and especially by night, is extremely prominent, in fact, it is often the first thing

that strikes the eye. On account of this very prominence, it is important that it be well chosen. It should not force itself on one, but should blend with the general picture. This can be readily accomplished by a little clever selection and placement. Something which just fits the scheme of decoration may cost a little more than something quite inappropriate, but this additional money is especially well expended.

Electric lighting possesses qualities presented by no other means of lighting. It is extremely flexible. Baseboard and floor outlets permit one to place a light anywhere in the room.

It is thoroughly safe and adaptable to any kind of a shade; silk, parchment, paper, glass, or metal. An endless variety of combinations of material can be called into play. Electric bulbs are so convenient that they can be placed anywhere; behind a cornice, in a vase, or wherever fancy dictates.

Electric lamps are standard in a wide range of sizes, from the little 10-watt, giving just a very small amount of light, to huge bulbs which are limited in power only by the commercial demand. Thus, the light for a room does not have to originate from one spot. It can be distributed so that there are just a few touches of light here and there where desired.

Another valuable feature has been mentioned above. This is the wide variety of color tones which can be obtained either with colored lamps or through the use of tinted gelatines or fabrics. There is no excuse for illuminating the residence throughout with the raw or unmodified light. One would not think of leaving all the walls, for example, in their original plaster finish.

With the possible variety in lighting, it is really a shame that such a high percentage of our homes are lighted in a most commonplace manner. One is prone to accept whatever form of lighting happens to be found in a house when purchased or rented; whereas, if the wall coverings were ugly, they would not remain long in service. Lighting is certainly much more important.

In view of the widely different tastes, it is almost impossible to completely cover the subject of residence lighting. The only practical method of treatment is to discuss in more or less detail the requirements of each room, having in mind the following elements: arrangement of outlets, type of fixtures ordinarily used, their advantages and disadvantages, where unsatisfactory

how they can be modified to be most suitable, style of glassware or reflector, type and size of lamp, and finally the possibilities in connection with each room.

PORCH.

In taking up rooms of a house in their logical order, the porch is naturally the first to receive our attention. As the porch is the part of the home which is most readily visible from the street, a well illuminated porch is an indication that the owner is doing his share in one respect at least toward the general attractiveness of the town. Proper lighting here in addition has an element of protection, for burglars and sneak thieves are more likely to pass by a house that has a porch light burning than one that has not.

Some porches merely serve as an entrance and require a low intensity of general illumination which spreads over the steps to avoid danger of accident. The wattage or size of lamp used here should be very small for it is desirable to have this light burning all the evening.

The unit most commonly employed for this service is a close fitting ceiling ring with a diffusing enclosing globe. Its advantages are that it is inexpensive and neat. A somewhat decorative type globe of opalescent or white glass is preferable to the round roughed glass ball ordinarily employed for it gives better diffusion. The porch light should not be permitted to accumulate a season's supply of dust and dead insects so often in evidence.

One of the greatest inconveniences, when calling at night in an unfamiliar locality, is to locate the desired number. A house number porch light is therefore a great source of satisfaction to both the owner and his friends. A number of types on the market show the numbers luminous against a dark back ground, at the same time transmitting light, through a portion of the fixture, which serves to illuminate the porch itself. Civic pride as well as personal convenience demands the installation of more illuminated house numbers.

In the better class of home, the porch is usually fitted as a room and used for playing cards or reading at night, and in such cases, they should be lighted in the same manner as a room and here an opportunity is presented for harmony of lighting. The use of cretonne shaded portable lamps which blend with the furniture

decorations is excellent practise. Weather proof flush receptacles at convenient points offer means of attaching such units.

The idea of outdoors can often be carried out on the porch and the sun-parlor or solarium presents opportunities for originality in lighting. Totally indirect fixtures are available provided the ceiling is of the proper light tone, and artificial vines hanging over the edge of the indirect unit give it an appearance of simply another group of foliage. Simple forms of direct lighting angle reflectors can often be used inverted as indirect wall bracket units. The night view in Fig. 1 is typical of such units. These are simple home-made fixtures. They appear to be baskets of flowers. They are in reality angle type steel reflectors with 40-watt Mazda lamps pointing upward. The problem was to find some method of hiding the mechanism or working parts of the unit. The owner resorted to a number of expedients; wooden boxes, composition urns, inverted bird-cages, and the like but none seemed to suit. Finally, the wife on one of her shopping tours spied some old-fashioned, green painted wire, hanging flower baskets. These were just what were needed and when filled with moss and artificial flowers served splendidly. The light showing through the orange black-eyed susans and red geraniums renders them luminous and full of life. This is an excellent example of making the lighting striking and yet so subtle that the result is accomplished without a thought arising in one's mind as to the means to the end.

HALL.

We pass from the porch to the front hall and find this room so varied in character from the mere vestibule to the luxurious reception room that it is difficult to make any general treatment. If it serves merely as an entrance, a single low wattage lamp enclosed in a diffusing glass globe is quite appropriate. Either the lantern type or fixture resembling a hanging urn is suitable. Three-way switches controlling this light are of considerable service. One should be located near the entrance door and the other at the head of the stair or in the upper hall.

Where the room serves for purposes similar to a living room, the methods of lighting described in connection with this are applicable. An additional outlet, however, in such cases is desirable. This consists of a bracket fixture with a low wattage lamp

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Fig. 1.—Night view of enclosed porch or sun-parlor lighted by two 40-watt Mazda lamps in "home-made" indirect bracket units resembling flower baskets.

Fig. 2.—Night view of a living room lighted by indirect table and floor lamps supplemented by wall brackets with silk sconces. The fabric of the shades harmonizes with the wall coverings and hangings.

Fig. 3.—A small den as it appears by night illuminated by a 50-watt white Mazda lamp in an ivory tone semi-indirect unit. A high intensity is provided at the desk by a suitable local lamp.

Fig. 4.—The artificial illumination of this dining room is accomplished by the use of a central semi-indirect unit with three 25-watt Mazda lamps. The tassel at the bottom of the glassware covers half of an attachment plug which serves electric cooking devices.

and diffusing shade at one side of the stairway. The 10-watt lamp for example is so economical that it may be burned all night forming an extremely effective burglar insurance as well as a convenience.

LIVING ROOM.

The next part of the house to receive our consideration may be known as the living room, parlor, library, or den, depending on local conditions. Here is the part of the home where probably the greatest opportunity is presented for artistic effects and originality. The widely diversified uses of this room give rise to different lighting requirements, and provision should be made for meeting these. When the family is gathered or when merely only a few friends drop in for a social evening, the maximum degree of comfort is attained by having a comparatively low value of general illumination supplemented by points of rather higher intensity. Every precaution must of course be taken to insure thorough diffusion of the light and elimination of brilliant light sources. When the room is used for a larger gathering, such as a card party or dance, it is desirable to have a relatively high intensity of evenly distributed general illumination. When the room is used by only one or two people, it is often preferable to have practically no general lighting and merely a certain area illuminated.

One of the simplest methods of meeting the above requirements is by the installation of a central unit of either the indirect or semi-indirect type so wired that two degrees (low and high) of illumination are produced.

The indirect units should be hung at such a height that the cut off, or edge of the circle of bright illumination, comes at the junction of the ceiling and walls or at the picture moulding. Often when gas filled lamps are used their rather concentrated filament causes sharp shadows of the supporting chains or hanger. In such instances, it is well to use lamps all frosted or where 50-watts per socket is adequate, the latest development in incandescent lamps, the white Mazda lamp, is especially well suited.

This general illumination should be supplemented by local or portable lamps served from base board outlets at various points about the room. These portable lamps may be in the form of the standard reading lamps, small art glass decorative lamps, and

the like. Color modification may be introduced by using superficially colored lamps in the main lighting unit or with properly selected gelatine screens.

The art glass and silk shaded lamps offer other opportunities for the introduction of a touch of color. Numerous pleasing effects can be produced by inserting small lamps in translucent vases, or ornaments. The writers recently noticed a touch of originality where a vase of flowers was located in a rather dark part of the room. A low wattage lamp in an inconspicuous reflector directed a beam of light on these flowers, rendering them luminous by reflection. Such effects as these are most interesting and appealing.

Instead of the central or ceiling unit, the general illumination is often supplied by wall brackets with suitably toned diffusing glass shades, silk shades or sconces, the design of the bracket of course being in harmony with the decorative period of the room. These also should be supplemented by the portable or table units. If gas filled lamps are employed in open top silk shaded portable lamps, a circle of very bright illumination as well as shadows of the support is cast on the ceiling. To prevent this affect, the top should be covered with thin silk, or other fabric, or diffusing bulb lamps installed.

The portable, table or floor, silk shaded indirect and direct lighting unit offers another solution of the problem of supplying general as well as local lighting. An example of such an installation is shown in Fig. 2. The most commonly used form employs an inverted mirrored reflector with a relatively large lamp pointing upward with a group of frosted smaller lamps for supplying the direct light. The general lighting may be toned by placing a sheet of colored gelatine across the mouth of the indirect reflector. The operation of a pull chain switch enables either the general illumination or the local lighting to be available at will. A similar effect can be produced by using a prismatic or dense opal bowl shaped reflector inverted within a silk or parchment shade.

Where a central unit takes the form of direct lighting, the silk shaded multi-arm candle stick fixture harmonizing with the wall brackets is often employed with splendid results. In the Colonial type of interior, the Georgian style chandelier with etched crystal shades and lamps burning upright is perfectly good taste, but not

as thoroughly comfortable on account of the relatively high brilliancy of the units as some of the other schemes which have been discussed.

The necessity for a generous number of base-board and floor receptacles cannot be too strongly emphasized as these make possible the display of individuality so much to be desired.

DINING ROOM.

The scheme of lighting best suited for the dining room depends on a number of factors: the size of the family, for example, having an influence on the type of equipment installed; the personal preferences of the hostess is also important. The scheme which has always appealed to the writers as being most satisfactory is to have a high intensity of illumination on the table top and the rest of the room in comparative shadow, not darkness. Such lighting as this concentrates the attention to the family group and provides a closer spirit.

Illumination of this character is produced by the "old-fashioned" dome. Where there is a large family, however, or likelihood of considerable gatherings, this method of illumination is not entirely satisfactory for it is difficult to get a sufficient spread of light from a dome hung at the proper height. Nevertheless, the dining room dome still remains a relatively important piece of lighting apparatus. The old style art glass dome was satisfactory, provided it was hung at such a height that the lamps used within it were not visible to those seated around the table. If hung higher than this glare was introduced. On the other hand, the hanging height should not be so low as to obscure any portion of the party sitting opposite one. The Japanese wicker domes with fabric lining are particularly well adopted to this class of service. To obtain a maximum efficiency out of these units, it is often desirable to hang a dense opal reflector over the lamp. (See Fig. No. 6.) This will direct the light downward on the table rather than allowing it to be absorbed in the fabric covering. It also prevents the filament of the lamp from being visible through the coverings.

Where a dome is hung so high that the lamps are visible, it is essential to cover the base of it with a piece of translucent silk. This may be tinted and in this instance, the warm tones are preferable as giving more pleasing appearances to the complexions.

Semi-indirect lighting is quite desirable in the home with a large family. This provides a relatively even distribution of light and is quite comfortable. A rather interesting example of this form of lighting was noticed where the ceiling was quite dark in color, in fact, a gray. A light density semi-indirect bowl was hung over the center of the table. The light transmitted through the bowl itself produced a higher intensity on the table than produced in the remainder of the room on account of the low reflecting power of the ceiling. Even in rooms where wall switches are not available, it is a relatively simple matter to install semi-indirect lighting for a switch can be attached to the ceiling, controlled by a pull cord, this being cut in on the service to the unit through a hole in the canopy.

A clever arrangement of a semi-indirect unit is shown in Fig. No. 4. At the bottom of this appears to be a tassel. This bunch of silk in reality covers an extension plug so that the heating and cooking appliances can be attached in this inconspicuous manner.

The candle stick has always held an appropriate place in the dining-room and it seems that this is one of the most logical places for the installation of the candle stick type fixture. If suitable translucent fabric shades are used with round bulb lamps and a candle stick fixture hung above the table, the maximum light will be directed down on the table top and a lower intensity prevail throughout the rest of the room. A scheme like this produces the same effect as the dome and yet gives a somewhat wider spread of light. A night view in Fig. No. 5 shows such a fixture properly installed and equipped with toned shades.

The lighting fixture should not serve as an outlet box or a place for the attachment of cooking devices. This is merely a makeshift arrangement. Baseboard receptacles or receptacles on the lower side of the table should preferably be installed. An example of a double gang box is seen in the rear of Fig. No. 5.

In some instances preference is expressed for low intensity of general lighting supplied by wall brackets with diffusing glass shades, silk shades, or sconces. The illumination on the table top itself being provided by means of candles, either natural or electric.

In certain houses the construction is such that an art glass window is found above the buffet space. A pleasing touch can

Fig. 5.—Night view of a dining room fitted with a candle-stick type fixture with five [illegible]-watt round bulb, all frosted Mazda lamps and silk shades. The double base-board receptacle to be seen at the rear is used for electrical appliances.

Fig. 6.—A convenient method of making a silk lined wicker dome effective and attractive, a semi-flared dense, opal reflector being used with a round bulb, all frosted lamp.

Fig. 7.—The lighting fixtures in this bedroom carry out the decorative scheme. The glassware used on the central semi-indirect unit and on the bracket fixture is beautifully decorated with poppies in delicate tints. A stand lamp not shown in the picture furnishes light when the owner desires to read in bed.

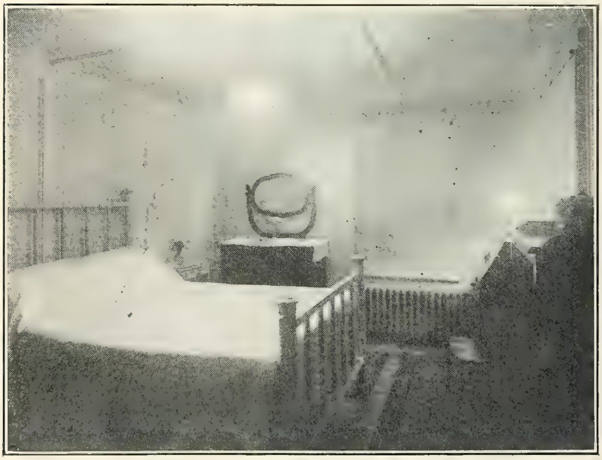

Fig. 8.—Night view of a bedroom lighted by a central semi-indirect unit, a bracket fixture, and a glass shaded desk lamp. The butterfly design is unique and is carried out on all three pieces of glass.

be produced by installing suitable angle reflectors and a number of low wattage lamps outside of this window. A ray of artificial light is directed downward giving the appearance of a beam of sunlight toned or tinted by the art glass of the window.

PANTRY.

It is quite evident that a relatively high intensity of illumination is desirable in the pantry to eliminate breakage. This can usually be accomplished by a simple type semi-indirect unit placed close to the ceiling. This can be obtained very inexpensively by utilizing a direct lighting opalescent glass bowl reflector and a harp type holder carrying this inverted below the lamp. It is often desirable to install wall outlets in the butler's pantry of a sufficient capacity for a small motor for polishing silver, an electric plate warmer, water urn or similar heating device.

KITCHEN.

The kitchen might properly be called the industrial part of the house and the principles of industrial lighting apply particularly to the kitchen. A high intensity of light of the proper quality will result in increased production, more uniform output and a higher quality product. Sanitation is enhanced with high intensity lighting, employees are better satisfied under the cheerful surroundings which result. Efficiency of lighting equipment is paramount in the kitchen. This is the one part of the home where it is desirable to get the maximum light on the work for the minimum expenditure of power. Direct lighting is most generally applicable. Inverted units in the kitchen depreciate quite rapidly on account of the prevalence of greasy smoke and the like, although lighting equipment of all sorts in the kitchen requires frequent cleaning. For most conditions, a simple stem or chain fixture with a dense opal or efficient prismatic reflector makes a lighting unit meeting the requirements outlined above. Two outlets are required in practically every kitchen. Satisfactory lighting cannot be accomplished in the kitchen with a solitary central outlet, particularly with direct lighting. With only one outlet in the kitchen when one is working at the stove, sink, or other pieces of furniture about the edges of the room, rather dense body shadows on the work are almost sure to result. The second outlet may often well take the form of a bracket fix-

ture, the overhead outlet providing the illumination at the range, table and the like, the bracket outlet being over the sink.

BEDROOM.

The bedrooms in most of our homes are inadequately illuminated due to lack of forethought when the house was being built. In the less expensive type of residence frequently only one wall bracket outlet is provided. This may give reasonably good light at a dresser or chiffonier but does not by any means fulfill the demands of the bedroom. A moderate intensity of general illumination throughout the room should be provided with more intense local lighting at certain spots. One of the most satisfactory means of meeting this end is the installation of a central ceiling outlet with suitable equipment. The local lighting is taken care of by bracket outlets and portable lamps. The lighter tones of wall paper and decorations prevail in the bedroom or boudoir, and in general a definite color scheme is carried out in all the decorations.

It is a most simple matter to carry this harmony through the lighting equipment. Etched and tinted glassware of infinite variety is standard and readily available. Some of the most beautiful examples of American glassware are to be seen in the equipment designated for boudoir use. Dainty, delicate floral decorations abound as well as the more conventional patterns. The better quality of this glassware is most artistic from every standpoint and very appealing. It is true that the high grade decorated glassware is somewhat more expensive than the type of shade ordinarily encountered in residence lighting but the personal satisfaction of having a unique and thoroughly pleasing installation certainly overbalances this. These semi-indirect bowls and shades are obtainable in various styles and a variety can be introduced from room to room. The portable lamp shades should be chosen to match both the central and wall units.

A haphazard selection of design of decoration should not be made. It is desirable to do a little shopping and find the particular unit which is most appropriate. This point cannot be too strongly emphasized for in this manner the most charming effects can be secured. A study of the glassware catalogues of the more

progressive manufacturers of decorated and tinted glass reveals some of the possibilities we have been trying to bring to your attention. Two typical examples of carefully selected equipment are to be seen in Fig. No. 7 and No. 8.

The side wall or bracket fixtures should be located near the dressing table, dresser, or chiffonier. A baseboard outlet is most desirable in the bedroom for the attachment of portable or reading lamps, heating pad, sterilizer, vibrator, curling iron, milk warmer, or other electric conveniences.

Where the room is used as a sewing room, a convenient outlet should be placed to which the motor for driving the sewing machine may be attached as well as a local light for sewing at night on dark goods. The reading lamp is often attached to the head of the bed or placed at a table at the side of the bed. Where only bracket outlets are available and it is desired to get a certain amount of general illumination, it is good practice to utilize open bowl reflectors of a rather wide type and turn the bracket so that it points upward. In this manner, a semi-indirect effect is secured without resorting to a ceiling outlet, sufficient light, of course, being transmitted through the shade to provide the higher intensity at the dresser or bed.

By way of variety, it is often desirable to utilize fabric rather than glass as the diffusing medium. Silk shaded wall units, central fixtures, and drop lights give excellent results, for variety rather than monotony should be the by-word of the lighting specialists.

It is desirable to provide an outlet in the clothes closet as this space is usually quite dark. This outlet should be located in the ceiling and may or may not be provided with a reflector depending on the ceiling height. If no reflector is used, then the lamp, usually of low wattage, should be all frosted. The use of a door switch for control of the light is a great convenience but the pull chain socket is quite common practice.

BATHROOM.

In the bathroom, the most exacting requirement is the suitable illumination of the face for shaving. If only one outlet is available, it is then desirable to provide two mirrors, one on each side of the lighting unit, although a much better practice is to

have a bracket outlet at each side of a single mirror. A simple type of semi-indirect unit in the center of the bath room ceiling is also very satisfactory. This provides excellent light for dressing the hair as well as for shaving. The usual white finish of the bathroom gives excellent diffusion to the illumination, eliminating annoying shadows and providing plenty of light from the side. In locating the bracket outlets for the bathroom care should be taken so that these are not opposite the window, thus avoiding shadows on the window shade. A wall receptacle with sufficient capacity for an electric heater, massage vibrator, shaving mug, hair dryer, or luminous radiator should be a feature in the well equipped bathroom.

CELLAR.

This is usually the work shop of the residence and good illumination should be provided at points where the work is done. The lighting should of course be entirely utilitarian as the decorative element does not enter here. Porcelain enameled steel reflctors with bowl frosted lamps at strategic points such as the work bench, furnace, etc., cover the lighting requirements of the cellar.

One of the outlets in the cellar, preferably the one at the foot of the stairs, should be controlled by a switch located at the head of the stairs. This insures sufficient light in the cellar to avoid accident. It is desirable to provide wall outlets for the attachment of grinders, buffers, drills, and the like.

The laundry is frequently located in the cellar in the form of a separate room. Good general illumination should be provided in this space and so arranged that shadows will not be cast when working at the ironing board, washing machine, or tubs. Wall outlets should be provided in the laundry for the attachment of iron, washing machine, mangle, etc.

It is obviously impossible in the time available to cover all phases of residence lighting or even to analyze completely the possibility of illumination applied to any one room. The authors trust that they have given a very brief bird's eye view of this broad question and awakened an interest in a feature of home planning which they are absolutely convinced will produce more comfort and satisfaction than any other.

DISCUSSION.

F. M. Feiker, (Chairman): This is a very practical paper and has given us a number of interesting suggestions. Some of the views in which the shadows were more evident than the lighting are more attractive than some in which the lighting predominated. I think it should be kept in mind that for home lighting, contrasts are more attractive than the more uniform intensities common in industrial and store lighting.

Another important point is the question of outlet and fixture location in rooms of different kinds. I remember when I was building a house some years ago I had my own ideas as to where the outlet for the small kitchen should be located. The electrician and the architect wanted it in the center of the room. I wanted it off the center, and had to change it myself three times before I could get the electrician to agree with me. I think there is room for a good deal of education in regard to outlet location.

There are two angles of the subject which might bear discussion: one from the viewpoint already brought out, and the other on ways in which we can interest more people in the points emphasized in this lighting discussion. Has anyone a point of view to express regarding this paper?

G. H. Stickney: Home lighting, in a way, has a peculiar relation to illuminating engineers—a little different from that of almost any other class of lighting.

In the first place, it is a universal problem. We are all personally interested in home lighting, independent of our profession. Therefore, we are less inclined to view it in prospective than we do most of the problems which we study from the outside. Again, individual taste is more the dominating factor, while engineering as such is likely to be a secondary consideration.

We find it difficult to establish standards and rules, and in their absence approach the problem in more or less of a haphazard manner. We do not have the guiding assistance of established practice, as in the case of store lighting and foundry lighting, and similar problems. The average installation is relatively small and seldom receives the expert attention devoted to other lighting problems.

As we survey the lighting installations in any city, we frequently find homes, which are otherwise well appointed and perhaps equipped with artistic or elaborate fixtures, but so illuminated that they are neither attractive nor comfortable during the hours of artificial lighting.

A study of the prevalence of poor lighting seems to indicate that it results from ignorance and false economy. Even in the poorer classes of homes, we find a considerable investment in decorations, such as furniture, wall coverings, floor coverings, etc., and it would not seem unreasonable for the home builder to make an expenditure for lighting which would be at least comparable with the interest on the investment in decoration, especially as the decorative effect is often more or less destroyed, when most needed, by poor lighting. Certainly, the difference in cost between poor lighting and good lighting is almost negligible, except as a first investment. The home is the bulwark of the Nation and its attractiveness more important than can be expressed in dollars and cents.

A very common fault in home lighting installations is the inconvenience of the equipment. Wall switches, for example, are frequently absent. I have in mind a home, costing nearly $10,000.00, in which none of the bedrooms are equipped with wall switches, so that it is necessary to cross the room in the darkness to turn on the lights. I have in mind another case where the tenant devised a very ingenious scheme of swinging around on a radius formed by grasping a door knob so as to find the pull chain of a center chandelier. It seems absurd to go thru such inconveniences daily, where a small investment, of the order of $5.00 per room, would have avoided the necessity.

The lack of baseboard outlets, is another common fault. Properly arranged baseboard outlets, particularly in living rooms, allow for the convenient installation of portable and table lamps, with which the housewife can arrange decorative lighting in spite of any deficiencies of the main lighting system. It further permits her to treat the lighting fixture as furniture and change the effect when she rearranges the room.

When a house is being built, there seems to be a very strong tendency to install what is cheapest rather than what is best. Much of this trouble appears to be due to the unlimited competition among contractors and the tendency of the builder or

owner to shop around for the lowest possible bid. Knowing of this tendency, the contractor is prone, even where good lighting is recommended, to see just how far he can cut down the cost of the installation by reducing the amount, quality of material and labor, in the hope that he can go further than his competitor. Under this condition, it is not surprising that poor installations result, often so bad that, when the house is occupied, it becomes necessary to revamp the lighting at an excessive cost.

In the majority of cases, however, especially in rented houses or apartments, the tenant simply puts up with the poor lighting. This seems to me a very unfortunate situation—not only does the contractor reduce his own business and limit the opportunity of others in the lighting business to serve, but actually gives a very poor result to the public.

If we are to have better lighting in homes, we must combat these tendencies and educate the people to demand flexible and attractive lighting facilities. Think how much better it would be for all concerned if we could produce a condition thru which those in the lighting business, to whom the public is looking for advice, could be induced to point out more attractive lighting effects and conveniences?

BEATRICE IRWIN: The foregoing remarks seem to suggest the thought that the important thing to consider is not so much the number of the outlets, as the quality of the light. The quality of light is greatly affected by the quality of our shades. When the shades are too transparent we are subjected to glare, and when they are too opaque there is an undue absorption of light, rendering the general illumination dingy. We can see, therefore, that among the most important consideration at the moment in connection with illuminating engineering are the quality of light in general illumination and the quality of shade employed for filtration of light.

In the majority of decorative shades found in department stores, the silk is so thin that we see the electric filament through it, or so heavy that only a spot of brilliant light appears beneath the lamp, and the rest of the room remains in obscurity.

I believe that it is very important that more attention should be given to the quality of our shades, whether they be used in connection with direct or semi-indirect light.

R. B. Burton: I find that considerable good work can be done by our members, in the way of propaganda in their own community by addressing women's clubs on better illumination for residence uses.

I recently had the opportunity to give a short talk on "Better Home Lighting" before a Women's Club in Mt. Vernon, a suburb of New York.

I spoke to some twenty-five women on the necessity of good lighting for their homes. Exhibiting about eight different types of glass shades suitable for bracket lights, and explaining the lighting value of different kinds of glass. Also explained by demonstration the increase in the brilliancy of the present Mazda lamps as compared to the old carbon filament lamp, and the great difference in the efficiency as well.

The point was brought out, that if semi-indirect lighting fixtures were to be used in the living room or parlor, that the glass bowl should be fairly dense, so as to protect the eyes from undue glare, usually noticeable in thinner bowls. If the glass bowl reflects approximately 75% of the light to the ceiling and 25% comes through the bottom of the bowl as direct lighting, a uniform and well diffused light will be obtained, and which will prove satisfactory for reading purposes, as well as make the room prove satisfactory for reading purposes, as well as make the room appear well lighted, and comfortable. Total indirect lighting was also shown in a different room, and the general appearance of things in the room, as well as the well diffused illumination furnished, was commented upon.

For the dining room; indirect lighting fixtures with silk shades, or four or six light candleabra fixtures are admirably used, being in good taste, and suitable for the purpose.

In bedrooms in general, if fairly large in size, a center fixture of either indirect or semi-indirect type, is suitable. In addition a drop pendant is many times installed directly in front of the dresser for the madam's use, and which proves very convenient at times.

For the bath room, a center fixture, in addition to a bracket or pendant over the lavatory is necessary and customary.

In the kitchen a center fixture is usually provided, in addition to a bracket light over the sink, for local use.

In general, it is best to recommend for the parlor, living room, library, dining and bedrooms, a center fixture in which design; a well diffused light is furnished, being reflected from the ceiling, allowing but a small part of the total light to be directed either thru the bottom or sides of the fixture in question.

The indirect component of the fixture should average around 75% and should furnish the effective illumination required; the direct component averaging 25% being utilized principally to bring out the color values of the glass-ware used, and also to enhance the artistic features of the fixture adopted.

Shortly after my talk, quite a few of the women in attendance made changes in the type of lighting fixtures in their homes, purchasing fixtures embodying the above principles, and I have been advised much improved illumination has been obtained, and the artistic features of the rooms have likewise been enhanced considerably.

No doubt many of our brother members living in our suburban towns, can also spread the gospel of good lighting in such a manner as above described.

W. T. Blackwell: Is it fair to educate the public before you educate the trade? The public looks to the trade for information. Ergo, it would seem that the education should first be given to the fixture manufacturer so he would carry a line of properly designed fixtures and secondly that the contractor who also handles fixtures should carry a line of fixtures well suited for the illumination of the home. The idea is not original with me. It was voiced by a fixture manufacturer at a meeting of the National Electric Light Association. "Why educate my trade before you educate me? Why dont you teach me what is right before you go out and spread your propaganda among the people and have them come to me and ask for something I haven't got?"

The French have a saying: "Cherchez la femme," which means "look for the woman" in the case. The woman dominates the home and usually selects the lighting fixtures. We as engineers stand no chance whatever of applying our formulas, in illuminating the home. Therefore the home is not lighted according to scientific ideas. It is purely a matter of education but along different lines than we have been following. We must educate

the women through their channels of information, viz: the women's papers; we must write articles on the subject of home illumination, etc. I have had it illustrated in my own home where I have been overruled in the matter of illumination. I have seen it demonstrated when other men, who were building their homes, have sought my advice and we have been promptly overruled upon meeting the ladies of the family.

The authors have brought out in their paper not only the question of convenience but also the point of harmony of color and decoration. These are all vital points, especially the one of educating the ladies as to the proper location of outlets, illumination, etc.

We have another phase of education and that is of the man who does the work. We, the Illuminating Engineering Society, constitute a very small percentage of the lighting industry. What we tell each other doesn't go very far. The people who do the work are the people we want to meet, namely the man who makes the fixture and the one who puts it up.

In small communities, like the country town, the electrical contractor invariably writes the electrical specification for the architect. Therefore educate your contractor. Your contractor naturally has a certain position to maintain in the town. The architect comes to him and says: "Can you write this specification?" "Of course, I can." He does it and you and I criticise the result of his efforts.

It seems to me that the whole problem lies in getting the message we have to carry beyond the circle we have here. If we feel that we know how to light industrial establishments and homes and other places, then we must disseminate that knowledge so that it gets to the right place, namely the man that does the work, the practical man. Very few of us reach the practical problem. I feel personally that until some concerted effort is made to bring these different factors in the industry together—not forgetting the ladies—that we won't get very far.

O. E. Eberhard: Propaganda is needed, similar to that in other lines. If, for instance, a man wants to build a house and desires to learn something about it, he can write to a cement

company or to the Portland Cement Association and get a booklet telling him how his foundation wall or his garage should be built. The Wallboard people will send him booklets showing attractive interiors finished with wallboard, and will even give him special service on his problems. Lumber manufacturers have booklets giving plans, methods of construction, etc. In other words, these firms tell the prospective builder or architect how their products can be used, and do not merely tell them of their products alone.

But if the man about to build writes a lighting manufacturer, he gets a booklet of lighting fixtures, and little or no information as to how they can be used to meet his individual problem. He receives no information as to where the fixtures should be placed or which ones are best suited to his house. The manufacturer should help such a man solve his problems and give him real service, sending him booklets that help him *know*. The average man depends on his architect, and in the smaller houses sometimes very bad advice is given. Neither the smaller architect nor the man about to build is helped to overcome his ignorance by the manufacturer. Consequently, little demand is made on the lighting contractor for high class service, and he merely gives what is called for. This is only human nature.

Now if the lighting manufacturers can be made to realize that good booklets will sell more fixtures, and more of the right kind, the trade in general will be benefited. Perhaps the Society can do something to make manufacturers realize this necessity.

E. Cantelo White: In regard to newspaper publicity, I think it would serve admirably. I have been a fixture dealer in my time and I know that the dealer is only about a lap or a lap and a half ahead of the public and that he thinks highly of anything that appears in the local newspapers than he does of any other medium because what little advertising he does is done in that medium and he appreciates anything that appears in the line of his business so that if you undertake to educate the public concerning the simple fundamentals of good lighting arrangements, you can count upon the average contractor and dealer to co-operate and prevent himself from being found asleep at the switch when they come around for lighting fixtures.

A. S. McAllister: In one or two cases illustrated flowers were used in connection with the fixtures—a very beautiful arrangement. Has any method been developed for minimizing the heat from the lamps on these flowers? It seem to me that the heat would prove very disadvantageous.

Chairman: These were artificial flowers.

A. S. McAllister: The heat has a bad effect just the same.

ADDRESS OF WELCOME.*

By Louis A. Ferguson.
Vice-President Commonwealth Edison Company.

It is indeed a great pleasure to have the privilege of extending for the electrical industry of Chicago to the Illuminating Engineering Society the welcome to our city.

I think it is something like eight years since you honored us with a visit and it may be interesting to you to know what we have been doing all that time.

Without telling you all that Chicago has been doing I will use a few figures of the Commonwealth Edison Company perhaps as a sample of the growth of the city to give you a quick idea of what has happened during that time. The income of the Commonwealth Edison Company since you were last here has increased from thirteen million dollars to twenty-six million dollars. The maximum load has gone up from 200,000 kilowatts to approximately 450,000 kilowatts. The number of our customers has increased from 157,000 to, in round numbers, 400,000.

I might mention that the population of Chicago has increased during that period 20 per cent., so you can see that the lighting industry has not only kept pace with the growth of the City but has really very far out-stripped it.

One of the most interesting figures of all, however, is the income per capita. That has increased from about $6.00 in 1911, when you were here before, to somewhere around $10.50, showing that our growth has been along the right line, that it has been prosperous.

When your committee spoke to me last spring about having the convention in Chicago it struck me that it was quite appropriate that it should be held here for, after all, Chicago is a great engineering laboratory.

About a quarter of a century ago, not quite one quarter, there was developed and applied here the first use of the combination of alternating current for transmission at high pressure and conversion into direct current for distribution.

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That system has since been applied in practically all of the large cities of the country and for the electrification of railroads, and probably the success of the centralization of production has been due to our ability to operate under such a system.

The steam turbine first had its application on a large commercial scale here in Chicago about seventeen years ago. It was then that the Fisk Street station was built. The first turbines installed were about 5,500 kilowatts. Prior to that time there had been made turbines, one single turbine of 500 kilowatts, and I think one of 1,500, but I am not quite certain as to that. At any rate the Fisk Street powerhouse was the first large turbine powerhouse that was built in this country. I recall, as though it were yesterday, the conditions under which the orders were placed for turbines by other cities, by New York and Boston and Cleveland and Detroit. The orders were placed with the General Electric Company and the Westinghouse Company, amounting to about 500,000 kilowatts, and they were all conditional on the success of the Chicago turbine. So you will see why I call Chicago a great engineering laboratory, because it was here that some of those things were done.

At the time the Fisk Street station was built the commission that was then working on the New York Central, headed by Frank J. Sprague, visited Chicago with the idea of finding out how we had approached the development of a large steam turbine powerhouse.

The introduction of Mazda lamps, while we do not claim that Chicago had anything to do with it, except indirectly, in a way, at the same time it is a little bit interesting. I happened to be in Berlin at one time. I don't recall exactly how many years ago it is, probably Mr. Doane would remember by knowing when the Mazda was first brought here, but I met our old friend, Bergmann, in Berlin and he told me in a very mysterious way about a wonderful lamp they had in Germany. After a good deal of persuasion I succeeded in having him get me one that I could bring back to this country. I remember very well the glowing letter I wrote to Mr. Insull telling him about this wonderful discovery and what it meant to the electric lighting business. Mr. John Howell was in Berlin at that time with General Griffin. They were on the same

mission. They were then studying trying to find out all they could about the tungsten lamp.

When I returned Marshall Field & Company were then considering revamping the entire lighting of their store, and the Westinghouse people were trying very hard to sell them Nernst lamps. Of course, naturally I tried to stop them because I was afraid Westinghouse would sell them an isolated plant and I did not want them to do that, so I talked to Mr. Shedd, who was then Vice-President of Marshall Field & Company about this wonderful lamp that I had found in Berlin. I told him I only had one of them and he wanted to know how soon I could get enough to fill his store. I told him it would probably take a year before they would be sufficiently developed in this country. So he went ahead with the Nernst lamp but as many of you know, it did not prove as great a success as was anticipated and the Tungsten lamps were finally put in there. That is another one of the developments on a commercial scale that we had here in Chicago.

One of the other things that we claim for Chicago is the use of the differential rate. We have been loyal exponents of the differential rate in Chicago for many years and we have adhered to it religiously. All our schedules of rates are based on the differential rate system, and had the gas companies of this country followed along the same line they probably would not be in the predicament they are in today.

But there are present day reasons why you should come to Chicago. We have here a representation of all the allied industries. We have lamp works, glass works and fixture houses with large displays of stocks.

Industrial lighting is another thing we have tried to do a great deal with here in Chicago and just at the present time it is particularly interesting when everybody is discussing the high cost of living. Our claim is that by increasing the standard of illumination in the factories we are able to increase or double the output of factories, and those of you who have been thinking along the lines of the high cost of living know there is only one solution for the reduction of the high cost of living and that is increased production. We can't expect to reduce wages in a hurry. Wages have been going steadily up, but if we can increase production it doesn't make so much difference what the wages are, provided the

increased production follows along a more rapid curve upward than the increase in the wages.

We have been carrying on an intensive campaign in educating the public to higher standards of light, and as a result of the control of the quality of lamps in this city we now lead all cities in the country in the candlepower of light per socket that is used.

One of my friends in addressing another body here recently spoke of Chicago as being the city of destiny. This city, as many of you know, is a great melting pot. We have all nationalities represented here, in fact, I think it is true that over half of the population of Chicago are foreign born.

We are often spoken of by critics as being crude and uncouth, but those critics forget that strength and loyalty and enthusiasm and patriotism and high ideals are not always found under a highly polished veneer.

Like Rome of old, all roads lead to Chicago. We have here, terminating in our city, twenty-seven trunk lines, and if all of the track mileage in the city of Chicago, within the city of Chicago, were stretched out in one line it would tie together the Atlantic and Pacific Oceans. As everybody knows, this city is the center of a great agricultural area, but we are now becoming a great financial center. I recall many years ago, perhaps twenty years ago, when it was necessary to raise $1,200,000 for the extension of our business. Mr. Insull found it necessary to go to London to sell Commonwealth Edison bonds, or then Chicago Edison bonds. At the present time, however, the big banks of Chicago are consolidating, merging into one so as to have a large enough working capital to handle almost any proposition that may come up here in Chicago.

Aside from our commercial claims, we feel that we still have something in the nature of culture. We feel we have some art here in Chicago and that is exemplified probably best by our Art Institute, our Chicago Public Library Building, our new Field Museum and the architecture of the University Club.

In music we feel also that we have a place. We have our Thomas Orchestra and if any of you are here on Sunday afternoon in the wintertime I can recommend to you nothing more enjoyable than to go to one of the concerts in Orchestra Hall or some other hall along Michigan Avenue, wherever it may

happen to be held, given usually by some prima donna of the Metropolitan Opera Company. They find here a welcome audience. You will find in that audience not the society people who attend the fashionable opera, but the real music lovers of this great city.

In medicine, too, we feel that we stand close to the top, even at the top. We have here many of the greatest surgeons of the country, many of the greatest internists and specialists of all kinds. Many of the surgeons of the east come here to attend the great clinics that take place in Chicago.

The motto of Chicago, as many of you know, probably all of you know, is: *I Will*, and that recalls to me, with due apologies to all my eastern friends, and I feel that I can say what I am going to say because I came from the east myself originally, I want to repeat what they ask a young man when he comes to three great cities in this country. In Boston, when a young man enters the city they say to him, "Who was your grandfather?" If he chanced to go to New York, they say, "How much money have you?". But in Chicago they say, "What can you do?"

I have an idea. This is entirely original, I think. I do not know how sound it is, but it is a reason for the virility of Chicago. As you know, Chicago is located on the southern end of Lake Michigan. The warm summer winds here are from the southwest. It happened that I spent part of the summer at Cape Cod this year and there the winds we enjoyed most were from the southwest, because they came over the ocean. Now, our corresponding energizing wind here in Chicago comes from the north, the northeast or northwest. I attribute the fact that we have virility in Chicago entirely to this great north wind. If we have a warm summer day or two days or three days or four days we know that finally that wind is going to get around into the north and we are going to stand again up on our toes. That is the thing that puts the go into Chicago, the great north wind.

Now for our present day attractions. At the moment we have to offer you the electrical show. We have to offer the drives through the boulevards. There are some fifty-five miles of boulevards in Chicago all connected. We have our park systems. We also have our forest preserves on the outskirts of the city, woodlands that have been taken over, acquired from private

owners for the purpose of preserving the woodland around the city for the people of the generations to come. Our suburbs we recommend to you. We feel that the men and women who come to Chicago and stop at a downtown hotel and then take the train back do not know what Chicago is. We feel that some of us would not live here if that was all there was to Chicago. But if you have the time and the opportunity to go about the suburbs of Chicago and see how the Chicago people really live I think you will appreciate that it is not such a bad big city after all.

In closing, I wish to say to you, ladies and gentlemen, the ladies have come in since I started speaking—that we hope you will take advantage of the entertainment which has been prepared for you and of whatever hospitality the lighting interests of Chicago may offer. We hope that you may come again. We always enjoy having you here and we hope that it won't be eight years before you make up your minds to come again. We wish to say to you in closing to just remember that "the latch-string is always out."

RESPONSE TO ADDRESS OF WELCOME.*

LOUIS B. MARKS.
Past President, Illuminating Engineering Society

Mr. Ferguson has recited the progress of electrical work in Chicago during the past eight years since our convention met here. The papers of the Illuminating Engineering Society will deal with the technical progress along the lines of illuminating engineering. It is my purpose only to say one word, a word of thanks, to Mr. Ferguson, in welcoming us here and in providing for us through committees headed by members of his staff, the magnificent program of entertainment that is listed before us.

I had intended to say a word or two about production but Mr. Ferguson took the words out of my mouth. If there is any one purpose, as I see it, for which we are gathered here, it is to assist the country in furthering production, and the one way in which we are particularly interested in this is in the illumination end of it. I would be remiss in my duty if I did not acknowledge here in my response to the welcome of Mr. Ferguson the most active part played by the Commonwealth Edison Company of Chicago in laying before the community for the first time, so far as I know, in an extensive way, the remarkable results to be obtained by adequate and proper illumination. Some one has said that they have shown the world how to Durginize our factories (laughter). We have a great program ahead of us and a remarkable work to be accomplished, and it is along the very lines upon which Mr. Ferguson laid stress that our convention on this occasion will deal with the subject of illuminating engineering in a one-half day program to be given next Wednesday.

On behalf of the members of the Illuminating Engineering Society and guests here assembled I thank Mr. Ferguson for his hearty welcome on this, the auspicious opening of the Thirteenth Annual Convention.

* Presented before the Thirteenth Annual Convention of the Illuminating Engineering Society, Oct. 20-23, 1919, Chicago, Ill.

ADDRESS.*

GENERAL GEO. H. HARRIES
Chief of American Commission in Berlin 1918-19.

There is no use of my telling you that I am glad to be back to see for myself and to testify to the steady growth in strength and I trust even in intellect of this organization.

It occurred to me this morning that this being an engineering society—that I might say a word or two—on the well-worn topic of efficiency: what I saw of German efficiency, largely in the field where Germany was supposed to be the most efficient of all nations. We all had a good deal of adoration for German efficiency, because perhaps it was a habit. That was the efficiency of many, many years of industrious effort, of amendatory thought, of the eliminating of what seemed to be in a military sense, useless things. It was another kind of efficiency than that, that we generally think of now. It was not the efficiency of lightning minds, the efficiency that becomes operative almost instantly or as rapidly as we can make and put in operation some new device. It is the plodding, careful, thorough something which we have called efficiency. So there, I say, for fifty years—but that is only the time since the Franco-Prussian War—yes, ever since the days of Frederick the Great, Germany has tried to be militarily efficient, and it would be a very remarkable thing if she had not reached a very high degree of skill in arms.

Now, how did her military efficiency work out? I was given the opportunity to see it work when it was facing in my general direction and another opportunity of seeing it when there was no longer combat, and when I could be right where the efficiency was supposed to have its central station after the war. There was a tremendous lack of vision. That would interest one section of this Society. There was a faulty sense of proportion, and that will interest any engineer. There was a complete failure to comprehend any other than German mentality, and fortunately for the rest of the world there were other mentalities than the Germanic. They had great confidence, a fixed confidence, in their

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own superiority. They in that way made so many things that would normally have been possible to a normal people impossible to them. They had a fixed and real belief that they were and are supermen. I have seen the plans of the German General staff, the complete plans. These, I may remark, were not displayed prior to November 11th, and there was no plan for the demobilization of the German Army in case of defeat, no suggestion of it, and when defeat came the machine fell apart.

Especially in the first instance was my attention directed to the record system. The system of records fell to pieces almost at once. Records, unkept records, abandoned records. I don't blame them for abandoning material in their haste, but still you like to keep your books with you anyhow. About the first thing you do when there is threat of a fire is to get your books out of the safe, unless you are interested in seeing the books go. The so-called system of food distribution had practically ceased to function and then when I entered Berlin it accentuated what undoubtedly had been the case in Germany throughout the war. The rich man alone could get food in reasonable quantity; of the kind, perhaps, not entirely what he wanted, but still consisting of many essential elements that were impossible to the poorer classes. There was no food distribution system worthy the name after the armistice. Of course there had been a political revolution, but the departments of the government after the revolution were staffed by identically the same men who had operated the departments throughout the war. There was no change. The man power was there, the officers were there and the material was all there, but the system fell. The same men are in office now, perhaps beginning a new system or picking up the loose ends of the old one. There is no change in the working forces. The only trouble was that the few, the very few directing heads were gone. We have seen directing heads go out and have perhaps, if we were friendly to them, wondered what was going to happen, but inside of forty-eight hours it was frequently demonstrated that there was a new directing head—a better man than the old one; and all of you who are not particularly directing heads just now will agree with me that that is easily possible. You see the German people had had no experience in governing themselves. Everything was purely automatic, and they placed very little con-

fidence in those who suddenly and surprisingly came into power. When the form of government changed only a king or a dictator could have averted the Spartacus outbreaks of January and March, and it was not until Noske became a dictator that any degree of internal peace could be secured. We must not, however, be unreasonable; we must not expect a new democracy to acquire at once that great governmental skill which is ours and upon which we congratulate ourselves—at times.

Germany had always had a socialist party. It was carefully cultivated by the ruling power. It was as tame a democracy as anybody ever heard of. Its business was to be, first, last and all the time, wholly under the control of the emperor and, secondly, to make as many real socialists outside of Germany as was possible. At the outbreak of the war or prior to that time the German socialists said they would never permit war and they shook hands with their French friends and all the other folks who were at the conference, but when the war broke out, why, those of you who know anything about German legislative history know that not only did the socialist leaders vote for but they advocated most strenuously all that the imperial powers wanted for war-making purposes. The German socialist has never done more than create an enormous amount of socialism outside of Germany. When the socialists in Germany, believing in themselves, and in what had been told them, at the time of the revolution attempted to be really active socialists intent on what we call direct action, or some such thing, why, they ran up againnst the autocratic German people who were not socialists, who did not have any real democratic thought, who were looking for the big autocratic, commanding voice to tell them what to do so that they might do it.

Reverting to the question of records: at the outset, prison camps where our own prisoners and the prisoners of our allies were, presented an interesting problem or succession of problems. I am within the mark if I say that the records haven't 20 per cent. of value, as compared with our records—the records of the Allies—which we believe to be fairly complete, quite as complete certainly as human effort can make them. There was no registration of a prisoner taken by the Germans and put to work behind the front lines. Of course that was doubly against all humanity and all rules of war. You must not work a prisoner at

the front lines, but the Germans did and the prisoners were not registered. No man was registered unless he got back to a camp, a prison camp, and then he might or might not be just depending on how the registration authorities felt about the matter and whether they were otherwise engaged or not. Prisoners were transferred, necessarily, from camp to camp, getting farther and farther to the rear. Each time they were transferred for a purpose and no record kept of their transfer from camp to camp. The bill of lading did not carry through at all on the changes of destination, so that there is no record of the tens of thousands who died, who were worked or starved to death or shelled in the front lines, behind the front lines or who died in some of the intermediate or rear camps. I wouldn't care to be quite definite about it because we have not yet all the figures in, but we shall have no missing ones in ours—for so far they have all been accounted for. Of course we got in late. We did not have the men who had been in prison camps, three, three and a half, four years or more. We believe we have accounted for every one of ours, but the British and the French will have in their minds and hearts we don't know how many people—in excess of 200,000 men—who will never be accounted for. No one will know where they died or how they died. Those who were killed just behind the front lines were buried at night in common graves. The enemy did not take the identification tags off and ship them to a neutral point so that there might be a record. I reached the conclusion at last that the inefficiency of records was something that must have been winked at by higher authority. I believe that Germany had organized only for victory, and in so organizing had taken no note of the prisoner problem and was prepared to say, had victory come to them, "We don't know anything about your prisoners. Don't bother us." I can't reach any other conclusion, and my conclusion is that of all the chiefs of the four Allied missions who were in Berlin.

Perhaps one of the finest evidences of inefficiency appeared in Berlin in December. I got in there ahead of the retreating German army. I thought I would like to be there to see them. The inefficiency was a psychological one aside from the fact that the returning ones were little better than a mass of stragglers. They were acclaimed by members of the government in speeches

delivered (and the bands played and the choruses sang and the flags floated everywhere) as "our unbeaten army." Now, no people who lie to themselves can be efficient. No man who deliberately falsifies the conclusion of a slide rule can be an engineer. That is what they did. They deceived themselves. They just lied to themselves and so "our unbeaten army" came home with laurel wreaths on their helmets and with flowers in their rifle muzzles and festoons on the machine guns and the bands playing "Deutschland uber Allies" and—you know this is funny—"Die Wacht am Rhein" when at that time it was absolutely impossible for any German outside of the occupied area to even look at the Rhine without a pass from me. Yet the bands played it a hundred times a day and great choruses sang it with abounding fervor.

Now Germany is coming back. The extreme left, the extreme socialist element, decided successively that seven hours and six hours and five hours would be a proper day's work, and as the hours of labor decreased so did the wages increase. They are working ten hours a day now. They realize there is nothing in the five, six or seven or even the eight hour day. They are back to ten hours and they are working for less money and they are working hard. So don't imagine that Germany is going to quit. The old German pride, the pride which a lot of us had who are not Germans, and some of us have yet in our work, in the thoroughness of it, is there, and the ability to perform is there, and the old spirit is alive again. So you are going to meet the German competition very soon. I have seen a good deal of their propaganda—both in the making and in circulation. I saw a lot of it in process of preparation. They are going to be as unscrupulous in their efforts to win markets as they are industrious. They are going to produce counterfeits in amazing quantity. You will receive a great deal of stuff not marked "Made in Germany" but in fact it will be made in Germany and it will appear to have been made in other countries as far as the markings are concerned.

I recall a seven-year old instance where a mill in the United States had the opportunity to supply a large quantity of cotton. The prospective Mexican purchase wanted it a little less in width and they wanted each piece of a certain length which was not in harmony with our standards. They wanted it cut and packed in a certain way because a great deal of it had to be transported

on mule back after it was landed in Mexico. The mill proprietors refused to make any changes whatsoever in their machinery or in their methods or in their packing, whereupon a German mill turned out cotton of the proper dimensions, properly packed. They had even put on it marking bands with the elaborate devices of the American mill and shipped it and got the business. They have got a lot of such tricks on hand and a lot of that general method is operating now.

There is no humility in Germany. I speak distinctly of Prussia, but it is true of practically all the country; Prussia emphatically as superior in its manner and as haughty as ever. There have been times when I have enjoyed inspecting the haughty element—because it didn't amount to anything and was cracked. I don't know how much illuminating you desire to do, but the German people need a lot of it. They need light. They need light which will show them that they sinned almost unforgiveably when they made war. They need light that will make clear to them the error of their unnecessarily cruel policy of war and devastating waste; light that will show them a sufficient but rather rocky road out of the savage darkness in which their alleged supermanhood was bred and that will render visible to themselves—their self-deceiving selves—the fact that when November 11, 1918 arrived, they, the German people, were militarily beaten; that a later demonstration would have been made had the Allied military powers had their way. If General Pershing's plan had been authorized in place of the—shall I say diplomatic, or possibly political, I don't desire to use harsh language—political plan which did become effective in the armistice there would have been no disturbance in Germany. There would have been the best possible method of equitable food distribution; a lifting of the blockade and everybody back to work; no Spartacus outbreaks; no unnecessary and very great loss of life and property, as there was during the spring and early summer. We would have occupied a certain number of strategic points throughout Germany. We would have said, at the proper time: "There is your treaty" and the Germans would have signed because we would have occupied their cities until they did sign. There would have been no argument about it; nothing to discuss. They would have signed and we would have moved out clean, leaving on Germany the unmistakable and

ineradicable stamp of "YOU'RE LICKED!" For the failure to do that, our military authorities were not in any sense responsible. The German people are not at all convinced that they were licked, because in their schools today, they are teaching the young German that a political disturbance in the rear of the army by a lot of highly unpatriotic and misguided people—some of them undoubtedly moved by foreign propaganda and British and American gold—wrought such injury that the empire had to give way to another form of government. That is what they are teaching; not five years from now or ten years from now, but now. But don't blame that on the army!

Meanwhile, so that we may not devote ourselves entirely to the illumination of Germans let us ask ourselves if we don't need a little illumination at home. Somebody might throw a searchlight on the immutability of natural laws which can't be disturbed by any man made statutes. The law of supply and demand, for instance. There has got to be an increased output or there can't be any decrease in costs. If we had, just to take a figure, ten billion bushels of wheat in the United States this afternoon and wheat was worth a dollar—that is an absurd figure I know, but I have been abroad—and tonight a fire, or whatever it might be, should destroy one-half of the wheat the other half tomorrow morning would be \$2.50. It would not double in price, because the shortage, of itself, would be alarming, and it would easily go to twice and a half times the price. The survival of the fittest is also worth thinking about once in a while. If we are not fit why we are not going to survive any more than did any of the nations whose unfitness and downfall is of history. Of course, we are satisfied that we are big and strong and that all sorts of things can happen to us without making a dent in us, but that is the Germanic method all over again. We are fooling ourselves. We have a lot of wastefulness and a lot of extravagance. I have only been home a few days but I have seen enough of it to convince me that there must be a complete reversion to wartime economies. I wonder what has become of the fine, thrifty war spirit. Of course, somebody will say, "Well, the war is over." Well, I hope so. We haven't ratified yet, but it is pretty nearly over—thank God for that—because as long as the ratification is incomplete all Europe, and especially those smaller peoples whom we have as-

sisted to national birth, are raising hell. We have got a nice lot of Balkans on the north. We were not satisfied with the old Balkans that could make Europe tremble any time they wanted to, so we created a relief for them and now they don't need to work more than half the time. We will have the northern group work alternate shifts and they are going to toil willingly until we have a definite policy and stick to it. I haven't counted today, I haven't had time, but yesterday we only had seventeen wars in full operation and any one of them would make good first page stuff for the newspapers if it wasn't for the fact that our people are tired of war. Everybody is weary except those who are at war, and they don't understand us and don't get our newspapers. Now the war after the war is a much more disturbing thing than the war itself. We have had a great volcanic disturbance that jolted the ends of the earth, that touched every nation, and you can't expect immediate subsidence. The lava is still flowing and the cinders are still falling. Now it happens to be a volcanic disturbance that we can have some check on. As a sound beginning, we can do a great deal to and for ourselves. We can be industrious; economical in every possible way, every rational way; be loyal to every basic principle of our government, of our form of government. We can respect the law and its officers. We can amend the statute if it is insufficient and we can supersede the officers if they are lax, but we have got to stick to the law. No departure from it; no variableness nor shadow of turning. This has got to be a government of law or this convention will go out of existence in common with a great many other conventions and give place to the Soviet. And the horror of all that I know. I have spent nine months with headquarters in Berlin, in intimate touch with every phase of military and social action from as far east as Omsk and north to the neutral countries, north of the Baltic to Archangel, to Constantinople in the south and across and through every one of the disturbed European countries, because my office was a central telephone and telegraph reporting center, and while my pay was not raised I did not strike. It was the one place that had to be in touch with all the activities. I know you have read many newspaper stories. I have seen only a few, a very few of them, but what I do know is that the men who have written or have tried to write have confessed to me

their utter inability to paint anything approximating a picture of what actually occurred or existed. I have seen or otherwise known of the dead and the mutilated and the wounded, not one or two or ten or one hundred or a thouusand, but tens of thousands, and I know what kind of a government, that government which is not of law, is, and I know what the people suffer. Now, of course, we will say there is no such possibility here. You would have said that certainly of Russia when she entered the war and that is not very long ago. You would have said: "I am perfectly sure that nothing of that kind ever could be." Then you will say: "Well, we are not Russians." You will say as my German liason officers used to say when I desired to parallel something they had done in Belgium perhaps, or in France, I would say, "Yet now you complain that this has been done to you. There is a perfect parallel." They would say, "Oh, but that's different." There is all the answer there was. There never could be any argument about it. It is different. You think it is different. It is not different. Law is law anywhere, and law which comes from the majority is the only law this country can stand and survive.

Now, I want to say to you what you undoubtedly well know. I happen to have seen it demonstrated a good many times in this past year. When you are thinking about the impossibility of anything approximating a revolution think a little while about the little revolutions that have been planned all over this country, that pop up here and there. Some of them came up too soon. They were premature and they have been damaged, but think of this, that an organized minority, a very small organized minority can run a great big majority off of its legs. I have seen a mob of 40,000 go out of business when it was faced by a battalion of infantry, and a short battalion at that, not exceeding five hundred men. They were German officers who had gone to the rescue of the German government and were organized in companies as enlisted men. The size of the mob didn't cut any figure. They cleaned that thing up in twenty minutes. So beware of the organized minority. You may say it is too small to think about; that they can't do anything; that the policemen will get them tomorrow. Don't you believe it. There has been a vast amount of money sent into the United States and a vaster sum has been

secured by contributions in the United States for the upsetting of our government. Now nobody expects it to be upset in five minutes or ten minutes or within a month or six months, but the propaganda is at work and the money is at work, and the first contribution toward that fund came from Germany just a little while before we entered the war. Germany's effort has always been to break up any alliance between anti-German allies; to break up the component parts of any hated country. It sent Lenine on a special train with all the funds he wanted into Russia, to do what? Just what he has done exactly. Now Russian money comes here. Having reached the verge of failure in Russia, he is anxious to exploit other countries. He can't exploit Russia much more. He is pretty nearly through there. He and his followers want to find new ground to work in. They tried to find it in Germany. Germany paid a great price for having started Lenine in business, because he turned on them and backed the Spartacus group against what was left of the old government. He double-crossed his partner. He kicked his benefactor. When he found he couldn't do anything in Germany he tried to do what he could in England, and he did a lot of damage there. He has worked in France and he did a lot of damage there. There is a good deal you haven't heard. The censor is still working, you know, over there. So don't imagine that Bolshevism is a little thing. Don't think it is something to be lightly spoken of and forgotten. Germany and Lenine won't let you forget it.

I want you to remember, and I haven't any doubt that you will, all the time, that service with the colors, in uniform, is not after all the greatest service that can be rendered, except when armed force is essential. Serving the colors is an ever-present possibility to every American man and every American woman. If each individual will only realize that such responsibility and such honor as comes to the man who is serving with the colors, can be secured by serving the colors (each one of us in our own place—whether we are in our best clothes or our working-garb) then we will make it impossible for any disturbing element or any combination of disturbing elements to upset the country that means so much to us.

ADDRESS.*

PRESIDENT S. E. DOANE.

It was a pleasure to be able to say to the old administration that they could take as much time as they wanted, especially when they brought us to Chicago where we could see the electrical show and some of the other things of which Mr. Ferguson has told us. I think Mr. Ferguson has modestly spared himself. He should have said that he has over in his building probably the most complete and best show of electrical fixtures, and in other respects, the best electrical store ever built. I think also that when one goes on Michigan Avenue at night he will agree that there is no more remarkable street by night than that broad avenue. We might go along further and enumerate many other things that Chicago has done. It was in 1905, I think, or possibly 1906, when Mr. Ferguson was in Berlin. We made the first lamp in 1907 I think it was the fall of 1905 that we first learned of the tungsten filament development.

The new administration has a remarkable opportunity. The war has taught us that we have been regarding electric lighting, to use a phrase that one of my associates has given me, as a janitor service, whereas we should have looked at lighting as an item in the cost of production or in the cost of sales, and regarded it as any other factor in the cost. Then we would have examined, as have men within the last year or two, under what light we could get the maximum of visual acuity or speed of visual reaction. During the war time we have had some demonstrations. Mr. Durgin has given the most and the best of the practical demonstrations of how to apply this knowledge that visual acuity increases with the intensity of light and the speed of reaction increases production. Its application to production has been spectacular, and the results have been remarkable. As a matter of interest and as a measure of our opportunities I would like to use some figures from the lamp industry. Sixty-five per cent. of the output of the lamp manufacturers, according to our estimates, is used in that portion of our business which would be

* Presented before the Thirteenth Annual Convention of the Illuminating Engineering Society, Oct. 20 to 23, 1919, Chicago, Ill.

affected by this knowledge. In other words, more than half of the electric lighting of this country can be affected and will be affected by the better knowledge we have of the production or increase in visual acuity and speed of visual reaction under intensive lighting. I hope that you will consider this convention entirely a matter of the other administration, and we hope that a year hence, as I said before, we shall have something of accomplishment to report to you.

TRANSACTIONS
OF THE
Illuminating Engineering Society
PART II -- PAPERS

Vol. XIV | DECEMBER 31, 1919 | No. 9

SYMPOSIUM—APPLICATION OF INDUSTRIAL LIGHTING CODES.

FOREWORD.

The *Industrial Lighting Codes* are new instruments designed primarily for the protection of workmen. Their educational influence is becoming recognized as a benefit to all phases of *Industry*.

We cannot overemphasize the importance of developing and applying the codes fairly and effectively.

An interchange of experience will not only help those responsible for enforcing the codes in each state, but will encourage the adoption of uniform regulations throughout the land.

Is it too much to hope then, that these presentations and discussions may contribute something to the welfare of our *Country* as a whole?

COMMITTEE ON PAPERS.

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* Read before the Thirteenth Annual Convention of the Illuminating Engineering Society, Oct. 20-23, 1919, Chicago, Ill.

Presented before a meeting of the New York Section, New York, N. Y., Nov. 13, 1919.

ADMINISTERING THE INDUSTRIAL LIGHTING CODE OF WISCONSIN.*

BY JOHN A. HOEVELER, ELECTRICAL ENGINEER,
INDUSTRIAL COMMISSION OF WISCONSIN.

INTRODUCTION.

Because the welfare of a state is inseparably linked with the physical welfare of its wage-earners, the state of necessity must interest itself in securing conditions of employment which will not diminish the health, virility and numbers of the working classes. This is a social question requiring social action, and justifies state regulation of safety and sanitation in places of employment.

But one may ask, why not let this matter to individual action? No man will work where he is not safe or where his health is endangered. No intelligent employer wants his men maimed, wants to ruin their health or see them killed in his place of employment.

If the wage-earner in present day industry had control over the physical conditions that affect his well being and even his life, your argument would have merit. But he has no such control. Complaint on his part may mean loss of employment rather than improvement of conditions. Even the potentially greater power of organized labor is ineffectively exerted, for various reasons.

Neither can we depend upon the employer to improve working conditions, because his principal business is to secure profits. True, many employers are doing much for their employees out of motives of humanity, and many more on the grounds of increased efficiency, but such motives cannot be depended upon wholly.

Not only because of the magnitude of the problem, but also because of its nature, regulation of the physical conditions in places of employment is a proper function of government. Moreover, without the aid of uniform legal regulations, the re-

* Paper prepared for presentation before the Thirteenth Annual Convention of the Illuminating Engineering Society, Oct. 20 to 23, 1919, Chicago, Ill.

calcitrant employers, be they a minority or a majority, cannot be brought to improve conditions.

Because poor lighting is positively known to be the cause of a considerable proportion of industrial accidents, and because poor lighting impairs vision, it is necessary to include lighting regulations in any code of safety and sanitation regulations.

Therefore, in 1913, the Industrial Commission of Wisconsin issued its "Shop Lighting Orders," the pioneer comprehensive code of industrial lighting in America. For reasons well understood by illuminating engineers, this code was ineffective. Therefore, in July, 1918, it was superseded by a new code. The new code follows the principles laid down in the factory lighting code of the Illuminating Engineering Society. It is the purpose of this paper to describe how this code is being enforced in Wisconsin, and the good that is resulting from it.[1]

Natural Lighting.—There is a general requirement which obliges the management of places of employment to supply working or traversed spaces in the buildings or grounds of the plant, with either natural or artificial light, in accordance with the succeeding orders of the code. Since all plants operate part of the time when daylight is not available, this proviso makes artificial lighting of the proper standard something which all employers must supply. Not so with natural light. Under the present code an employer conceivably might build his buildings without windows, assuming he could still comply with other sanitation requirements, if artificial light complying with the code were supplied during all the working hours. If, however, the plant depends upon natural light solely during any part of the working hours, the daylight must conform to the standards set forth in the code.

The intensities of natural light supplied to working areas must be twice the intensities called for with artificial light. Moreover, awnings, window shades, diffusive or refractive window glass must be used where there is chance of glare in the eyes of the workers due to direct sunlight or bright skylight.

An order of the commission relating to building construction requires all plans of new buildings or additions and improve-

[1] It may be well to state that the code is applicable only to new installations. Existing installations need not be brought up to code standard until July, 1920.

ments to existing buildings to be submitted to the commission for approval before construction may be begun. While this requirement refers only to the construction of the building itself, plans received are also examined as to the natural lighting facilities. In this way, the owners may be advised as to the natural lighting requirements of the lighting code. They are also advised as to advantageous methods of arranging machinery and equipment. In all cases, owners are urged to provide the best natural light obtainable under the circumstances, because of the greater satisfaction of a "daylight shop."

Where the field inspectors find conditions in buildings that are admittedly bad from the standpoint of glare, they have been instructed to order corrective measures to be taken. Since no measurable limits of glare from windows are given in this code, this becomes a matter of individual judgment on the part of the inspector. Hence, only the very bad cases receive attention, and this is as the commission wishes the matter to be handled, the prevention of glare from natural light being rather expensive and sometimes difficult of attainment in a practical manner.

Artificial Lighting.—During those working hours when the natural light is less than twice the intensities required for artificial light, artificial light must be supplied which complies to the code. Again when the plans are received by the building department, they are examined to see what, if any, provision has been made for adequate artificial lighting. When necessary the commission advises the employers how to proceed to get proper artificial lighting. From the nature of the case, however, this advice can cover only the broad outlines of the problem. To secure the benefit of the individual study necessary to an adequate solution of any particular lighting problem, the owner is advised to secure the services of the lighting specialist. For this purpose the commission believes the independent illuminating engineer should be retained, but if the factory manager personally undertakes to decide as to the lighting system to be employed, or if he places this responsibility upon his electrical department, he is advised to at least avail himself of such commercial engineering services as can usually be obtained from the local central station, from first-class electrical contractors or from reliable manufacturers of lighting equipment.

In many instances, the illuminating engineer of the commission visits the plant and goes over the lighting question with the management on the ground. In such conferences the management is requested to have the plant electrician or the electrical contractor present, if the electrical work is being done by an independent contractor. Such conferences serve the dual purpose of aiding the employer to comply with the code in the present instance and of educating the electrician or contractor in the principles of better lighting. As time goes on fewer and fewer of these conferences will be necessary, because it is expected that the electricians will be able to handle the work satisfactorily as soon as they become better acquainted and more experienced therein.

While existing installations as yet are not affected by the code, nevertheless the inspectors have been requested to report on the lighting of the plants they visit. They make no attempts at measurement of the intensity of illumination at the work, so that only the worst cases of insufficient illumination are reported. They observe rather carefully whether or not lamps are adequately shaded, but make no measurements of brightness of the light sources. Since opaque reflectors are in almost universal usage, however, a proper depth of reflector practically insures compliance with the orders relating to glare. The inspectors make it a point to bring the lighting code to the attention of the employers, where it is obvious that improvements in the lighting will be required.

Since the minimum permissible intensity values are rather low, it is not anticipated that great increases in the illumination of the plants of the state will be forced by the code. Changes forced by the code will consist more of additions of lamps to improve distribution, installation of reflectors to avoid glare, provisions for emergency lighting and night lights.

The question of emergency lighting designedly has been left open to the exercise of discretion on the part of the commission in its enforcement. The purpose of the order is to guard against accident due to the failure of the regular lighting system. In administering this order the commission takes into consideration the amount of protection necessary under different circumstances, and this depends upon the size of the premises, the extent of the

hazards of employment, the number of employees, and the means available for supplying such emergency lighting. Under no circumstances would the commission feel justified in demanding emergency lighting, the cost of which would be out of proportion to the protection required.

The spirit of the emergency lighting order requires that the emergency lighting system be kept entirely separate and distinct from the regular lighting system, and that it be made as reliable as is humanly possible. Therefore, the system should be installed in a first-class manner, and thereafter frequently inspected and the necessary renewals of parts and repairs made. The commission makes the following general recommendations:

Electrical emergency service should, when possible, be taken from mains that have no connection with those supplying the regular lighting system. In the case of factories supplied with central station service, the emergency system should be supplied from mains from a separate station, sub-station or transformer; whereas factories supplied with isolated plant service should arrange for (1) central station service for the emergency system (2) service from another isolated plant, (3) service from a storage battery, or (4) service from a separate generating unit driven by a separate prime mover.

In the case of factories supplied with electrical energy from central stations, it may be impossible to get emergency service from a separate main. Under this condition it becomes necessary to take the emergency service from the same main as the regular lighting system service, but the emergency system must be supplied from a separate service direct from the main, and it is good practice to make the size of this service several times heavier than required and fused accordingly, so that the emergency system is not likely to be rendered useless by the blowing of the service fuses.

Gas lamps provide a very satisfactory means of emergency lighting, where gas service is available.

Lectures to Contractors' Associations.—Early in this work with the Industrial Commission of Wisconsin, the owner of a small woolen mill made this statement to the writer:

Your first job, if you want to get results, is to educate the electrical contractor on this subject of factory lighting. He is the man we employers depend upon for expert advice in electrical and lighting matters. I just had this lighting installed a few months ago, as you can see for yourself, and now you tell me it is all wrong.

This man is right. It is the contractor's business to know

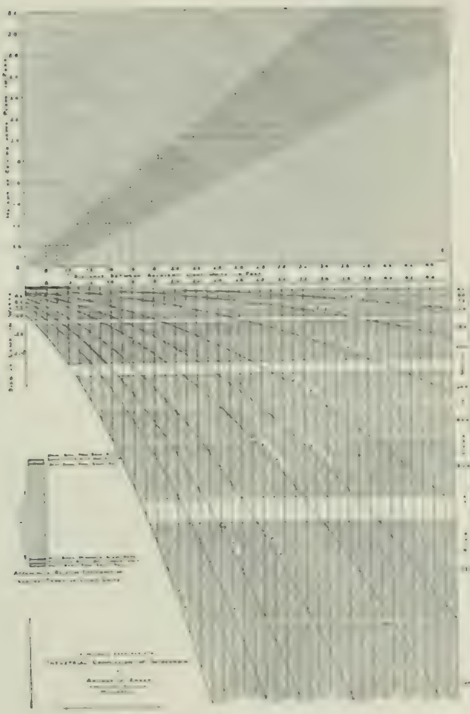

PLATE I. ELECTRIC LIGHTING

For determining the proper spacing and size of incandescent tungsten lamp to produce the intensity of illumination specified by Order 2112.

Note:—This chart refers to illumination on a horizontal plane [illegible]. Type B means vacuum tungsten lamp. Type C means gas-filled tungsten lamp.

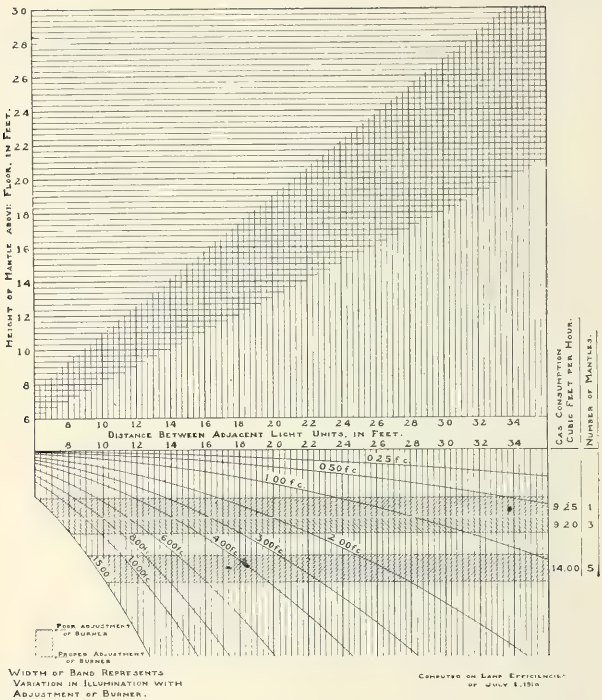

PLATE II. GAS LIGHTING.

For determining the proper spacing and size of gas lamp to produce the intensity of illumination specifies by Order 2112.

Note :—This chart refers to illumination on a horizontal plane 36 inches above the floor.

something about shop lighting, and the Industrial Commission of Wisconsin is giving attention to aiding the contractor in acquiring this knowledge.

In addition to the individual conference with the contractor on a particular job, the illuminating engineer of the commission lectures to electrical contractors at their meetings. The details of the lighting code are gone into and ways and means of designing lighting installations to comply therewith outlined. Emphasis is laid on the function of the Wisconsin lighting code, or indeed any lighting code. The contractor is made to clearly appreciate the fact that the code does not specify the lighting practice which will insure best practice, practice that has been shown to result in increased production and decreased spoilage of material; that on the contrary the lighting code does nothing more than establish the minimum lighting service which will sufficiently safeguard the safety and health of the wage earners. The contractor is urged to do his best to convince the employer that it is highly profitable to provide materially better lighting than that which will barely meet the requirements of the code.

Emphasis is laid on the fact that really adequate lighting is something more than providing a sufficient quantity of light, that proper quality of light, proper direction on the work, freedom from objectionable shadows and conditions suitable for the eye to perform its functions without excessive fatigue are other important factors requiring the attention of the contractor.

Part II of the Wisconsin Industrial Lighting Code which is devoted to an explanation of the provisions of the code is used as a text for these lectures.

A most useful portion of this explanatory material is two charts for determining the proper spacing and size of incandescent tungsten or gas lamp to produce the required intensity of illumination at the work. These charts, which were prepared for the commission by Arthur J. Sweet, are reproduced, herewith.

The upper parts of Plates 1 and 2 present the data from which the proper spacing between lamps can be satisfactorily determined for common conditions of installations. The vertical scale to the left indicates the height of ceiling above floor or in cases where lamps are suspended at some distance below the ceiling, the height of the lighting unit above the floor. The lower hori-

zontal scale indicates the distance between adjacent light units in feet. The minimum and maximum spacing values for any height above the floor, as indicated by the shaded area, give the desirable spacing limits. Spacings nearer the minimum value will produce better uniformity and diffusion than those nearer the maximum value. In any event spacings greater than the maximum should not be employed if reasonably uniform illumination is desired.

The lower parts of Plates 1 and 2 indicate the size of lamp required to provide a given intensity of illumination with a given spacing in feet. The points of intersection of the vertical lines representing the distance between adjacent light units and curves representing various footcandle intensity values determine the size and type of lamp to be used. Thus with 20-foot spacings between lamps and a desirable illumination of 3 footcandles, we find the intersection of the vertical line representing 20 ft. with the curved line representing 3 footcandles falls in the horizontal band representing the 200 watt gas-filled tungsten lamp. The width of the band represents the difference in efficiency of various types of lighting units. From the small diagram to the left of Plate 1 it will be noted that two types of reflectors fall nearer the top of the band and three types nearer the bottom, therefore, in the particular example if either of the two types of reflectors are used, which fall nearer the top of the band, the illumination produced will be somewhat less than 3 footcandles, whereas if one of the three types of reflectors which fall nearer the bottom of the band is used, the illumination will be somewhat greater than 3 footcandles. In the case of Plate 2, the width of the band represents the variation in illumination with adjustment of gas lamp burner.

These plates are computed with reference to a horizontal plane 3 ft. above the floor. If, therefore, the work to be illuminated is chiefly on a horizontal plane, the charts may be directly used to determine the proper size of lamp, and will be found to be reasonably accurate. If, however, the work is chiefly in a vertical plane, the problem of proper lamp size is more complicated and can only be determined roughly by general data. The ratio between the horizontal illumination and the vertical illumination depends upon the position of the light units in front

Fig. 1.—Lighting codes aim at preventing such flagrant cases of [illegible] illumination, [illegible] shadows and excessive glare as here shown.

Fig. 2.—Conditions such as these it is easy to appreciate contribute to the [illegible]

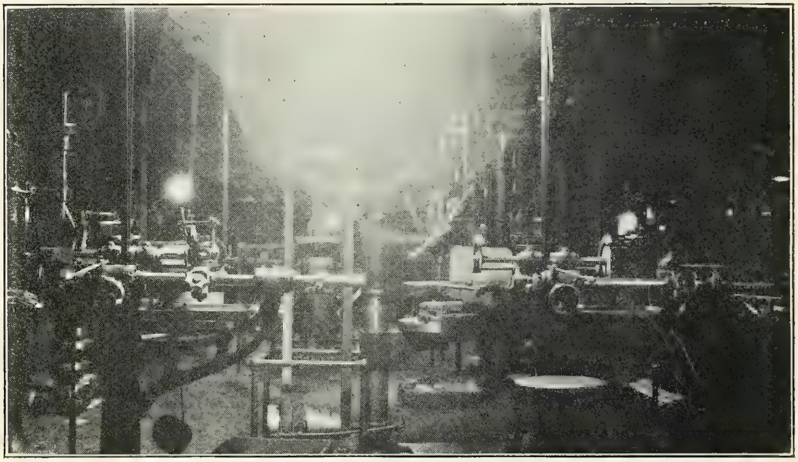

Fig. 3.—High power insufficiently shaded overhead light sources suspended at low elevation cause glare and uneven illumination. Such conditions are bad for the eyes, and a wage-earner who is compelled to work with such illumination year in and out is sure to suffer impairment of vision.

of the work and the degree to which their light can illuminate the face of the work, and also the type of reflector employed. The first of these factors depends very much upon local conditions, and no attempt has been made to give general data thereon. As for the second factor, the approximate ratio between the vertical and the horizontal illumination is given in a table for the various distinct types of reflectors. These relations as given in the table necessarily are approximate, and vary considerably with varying conditions of installation. They vary but slightly, however, as between various makes of the same type of reflector.

Lectures to Factory Managers, Superintendents, Foremen.—It has long been the custom of the industrial commission to deliver illustrated lectures at meetings of plant managers, superintendents and foremen. The subjects have been various phases of the safety and sanitation movement. Latterly industrial lighting has been a subject of these meetings. The attempt is made to give the shop men an idea of the principles of proper factory lighting by means of lantern slides. Illustrations of both poor and adequate lighting are shown for purposes of comparison. Technical discussion is expressly avoided. The aim of the talk is merely to give the shop man a better idea of what can be accomplished in the way of improved lighting. Methods of procedure are discussed in general terms only.

One purpose of these lectures is to wake up the managements to the value of better illumination, and another to acquaint the men with the subject. It so frequently happens, that where the men have never seen proper lighting, the management will encounter resistance on the part of the workman, when proposing improvements in the lighting. This resistance proceeds from ignorance and can be overcome only by education.

Monthly Meetings of Factory Inspectors.—Each month the factory inspectors from their various districts are assembled for an all-day meeting. At these meeting experiences are exchanged and new phases of the work discussed. This gives the illuminating engineer of the commission the opportunity of discussing industrial lighting with the inspectors. In this way, it is hoped to improve the knowledge of the inspectors as regards lighting, so that they can talk better lighting, to the employers they meet,

in a convincing manner. Frequently inspection tours of well lighted plants are arranged for the evening of the meeting. A footcandle meter is taken along and illumination measurements are made, as well as observations of the presence or absence of glare and shadows. These inspection tours have been productive of much good in acquainting the inspectors with the problems of factory lighting, and has made some of them enthusiastic proselytors of better shop illumination.

Illumination Surveys and Inspections—Shoe Factory.—The first factory the industrial commission requested the writer to visit was a shoe factory in which the lighting was very poor. But very little general illumination was provided and such units as were in use were exposed full to view and a source of glare. Each machine was supplied with one or more local lamps, some naked and some shaded.

About as many different designs of reflectors were in use, as I believe, could be brought together in one place and they would have made excellent material for an exhibit of lighting curios. None provided adequate eye protection; all were old and dilapidated; all were dirty; they partially shaded the lamps but added little to the effective illumination on the work.

After going over the factory with the superintendent and pointing out the total inadequacy of the lighting system, I asked him if he would not put in a modern installation in one section of his plant so that he might learn for himself what good illumination would do for him in reducing accidents, relieving eye strain and increasing production.

He said, "Why, yes, I am just changing over a department preparatory to making army shoes, and some lighting equipment will have to be installed: I will instruct our engineer to put this in according to your recommendations."

The department in question was fitted up with 100-watt gas-filled tungsten lamps, equipped with shallow-bowl porcelain-enameled reflectors with a screening angle of 15°. The units were installed at an elevation of 10 ft. above the floor and so spaced as to produce an intensity of 10 footcandles on a horizontal plane at the work. Such a high intensity was provided

because the artificial lighting was required the entire day, mixed with an insufficient natural light.

The installation made good quickly. Within three months $4,000.00 was expended in fitting up the entire factory in a similar way, and $3,000.00 was expended in improving the natural illumination by treating the interior with two coats of white paint.

Properly illuminating this factory brought inquiries from other shoe factories of Wisconsin, so that to-day quite a number of these are well equipped, especially in the new additions which have been erected.

Metal Working Plant.—Another of the plants visited early in the work was a metal working plant making automobile parts. Several interviews were necessary before it was possible to interest the superintendent in better lighting, and it was thought advisable to make a rather complete survey of the lighting facilities[1] (both natural and artificial) of the plant so that we could talk in more definite terms of the faults of the illumination. The survey undertaken secured the following data:

(1) Measurements of floor area and window area; notations of manner in which windows were distributed; degree of cleanliness of the window glass; measurements of coefficient of transmission of window glass when dirty and after having been cleaned.

(2) Data as to number, type, size, arrangement, condition and cleanliness of the artificial light sources.

(3) Measurements of the illumination in footcandles at the work for both daylight and artificial illumination. Simultaneously with the daylight measurements at the work, measurements of the sky brightness were made.

(4) Data as to the kind of work performed, arrangement of working planes with respect to sources of light, color of walls and ceiling, character of shadows, and glare from light sources.

Portions of the report submitted to the superintendent follow:

[1] The Industrial Commission of Wisconsin was assisted in this work by Mr. Davis H. Tuck, at that time (summer of 1917) illuminating engineer of the United States Public Health service. Mr. Tuck and the writer spent five months visiting and making surveys of plants engaged in war work and the test data herewith submitted was secured jointly by us, following in general the plan pursued by Mr. Tuck in surveys made in other states.

Natural Illumination.—In making the natural illumination survey in this plant, typical areas were chosen, and for each such section, photometric measurements were made on every working plane included in the section. To indicate the complete character of the survey, the detailed illumination, measurements taken in the drop forge die tool department are given in the following table:

TABLE I.—DROP FORGE TOOL DEPARTMENT.

Work plane[1]		Illumination in footcandles on horizontal surface[2]	Remarks
Bench		0.27	Bench runs along south partition.
"		0.48	
"		0.70	
"		0.78	
"		0.17	
Milling machine	314	0.23	
" "	T99	0.82	
" "	T85	2.80	
" "	T101	3.2	
" "	T94	1.8	
" "	T27	0.58	
Lathe	24	0.54	
"	T86	0.35	
Drill press	A39	0.38	
" "	T97	1.20	
" "	P184	0.20	
Grinder	T95	5.80	
Shaper	T93	0.54	
"	T103	0.41	
"	T100	0.62	
"	T382	0.11	
Planer	T40	6.3	
"	T45	0.53	
Bench		5.0	Bench runs along north wall. Workman faces window.
"		3.5	
"		7.0	
"		5.1	

Note: Windows in north wall only. Windows face narrow court between buildings.

It will be noted that the maximum intensity secured at the bench along north wall windows is 7 footcandles; the minimum intensity at shaper 382 is 0.11 footcandle, when normal exterior daylight conditions obtain (sky brightness of 200 candlepower per square foot), and the ratio of

[1] Point at which work is done.

[2] Footcandle values reduced to a common basis of a sky brightness of 200 candlepower per square foot.

Fig. 3.—A Wisconsin shop which is illuminated in a manner calculated not to hinder production. The lighting is materially better than the code requires.

Fig. 5.—Advanced employers in Wisconsin are using indirect lighting to some extent where high-grade work is done as in the manufacture of hosiery and knitted goods. This form of lighting is far in advance of what the code requires with respect to glare.

maximum to minimum is 63.6. For daylight conditions, the optimum intensity of 7 footcandles proved to be barely satisfactory for working purposes. Hence it may be said that this entire department is under illuminated when natural illumination is depended upon, and normal exterior daylight conditions obtain.

Similar data was taken in other departments, but only the maximum and minimum values are listed.

TABLE II.

Department	Max. Illum. Footcandles	Min. Illum. Footcandles	Ratio Max. Min.
Tool department	2.7	0.05	54
Motor wheel assembly department	5.0	0.84	6
Motor wheel engine assembly department	4.2	1.2	3.5
Grinding and punch press department	9.2	0.34	27
Punch press department ..	1.2	0.04	30

In all these departments it will be apparent from the above that the illumination at most working positions is below what experience has taught to be necessary. In checking up the glass area as compared to the floor area, it was found that there was 1 sq. ft. of glass for each 5.75 sq. ft. of floor area, but the glass area was apportioned in a rather ineffective manner, was found to be very dirty, ceilings and walls were very dirty, and overhead belting and shafting also decreased the illumination from dormer skylights. Measurements of the light absorbed by dirt on the windows showed the absorption to vary from 35 to 69 per cent.

With these results as a basis, the following recommendations are made: Steps should be taken for improving the daylight by (1) thoroughly cleaning the windows, and (2) finishing the ceiling and upper walls in white. It is particularly desirable that the ceilings in the dormers and monitors be finished white as this would add much to the effectiveness of the natural lighting. Thus the favorably situated areas would receive adequate natural illumination during a large part of the day, a desirable condition.

Artificial Illumination.—The artificial lighting of this plant is of two distinct types:

(*a*) From overhead units elevated 7 to 10 ft. above the floor;

(*b*) From drop lights suspended close to the work.

The practical absence of anything in the nature of a uniformly arranged system of general illumination leads to a condition of great variation in the intensity of illumination at the work (as will be seen by inspecting the following table which gives complete data on the drop forge die tool department) and the consequent necessity of supplying a local lamp at each machine.

TABLE III.—DROP FORGE DIE TOOL DEPARTMENT—ARTIFICIAL ILLUMINATION.

Working plane[1]		Illumination in Foot-candles on horizontal surface[2]	Remarks
Bench		0.32	Bench runs along south partition.
"		1.4	
"		1.1	
"		2.6	
"		2.1	
"		0.62	
"		2.4	
"		1.7	
Milling machine	314	1.4	
" "	T99	1.0	
" "	T85	9.6	
" "	T101	0.20	
" "	T94	2.7	
" "	T27	0.23	
Lathe	24	2.8	
"	T86	0.80	
Drill press	A39	0.62	
" "	T97	1.1	
" "	P184	0.62	
Grinder	T95	0.38	
Shaper	T93	2.3	
"	T103	3.8	
"	T100	1.9	
"	T382	0.45	
Planer	T40	0.46	
"	T45	0.22	
Bench		0.94	Bench runs along north wall; workman faces windows.
"		0.93	
"		3.3	
"		1.8	
"		0.93	

The maximum and minimum intensity secured by the artificial lighting system in other departments are tabulated below:

[1] Point at which work is done.
[2] From overhead lamps only.

TABLE IV—ARTIFICIAL ILLUMINATION.

Department	Max. illum. Ft. candles	Min. illum. Ft. candles	Ratio Max. Min.	Watts per Sq. Ft.	Remarks
Tool dept.	10.5	0.04	263	0.55	Local lights required.
Motor wheel assembly dept.	5.0	0.15	33	0.48	"
Motor wheel eng. assem. dept.	2.8	0.22	14	0.42	"
Grinding and punch press dept.	7.9	0.50	16	0.21	"
Punch press dept.	0.94	0.01	94	0.31	"

Note. Illumination values are for overhead lighting units only. As indicated under "Remarks" local lights were required at most machines.

Except for the relatively few points of high intensity noted in the above tables, the illumination from the overhead units is much below the requirements for easy seeing. The result is a few spots of high intensity against a background of very low brightness and the absolute necessity of local lamps on practically all the machines. These local lamps are an additional source of eye strain because they are exposed, and it is apparent that the glare is unbearable to many of the workmen from the fact that 37 per cent. of the local lamps in the departments tested are equipped with makeshift paper or emery cloth shields. These local lamps are suspended from long cords attached at the ceiling, making it next to impossible to adjust the lamps and fix them in the best position with respect to the work. As a consequence, they are frequently hung in such a manner as to shed little or no light upon the part worked upon. Consequently, the workman must hold the lamp in the proper position, thereby reducing his output due to time lost in holding his lamp in position.

The lighting equipment of the departments listed in the above tables was inspected to secure an idea of the effectiveness of the maintenance in the various departments, and to arrive at an approximate figure, by inspection, that would denote the degree of maintenance. The following table, which shows approximately the efficiency of maintenance resulting from loss of light due to the corresponding condition, was adopted:

Condition	Efficiency of maintenance
Lamp dirty	80
Lamp very dirty	70
Lamp blackened due to aging	80
Lamp too large or small for reflector	80
Lamp missing, broken or shorted	50
Reflector dirty	80
Reflector very dirty	70
Unit loose or cord bare	80
Reflectors cracked	80
Reflectors broken or missing	50

To illustrate method of application, a sample calculation is given for the tool department. Twelve units, lamps dirty, reflectors dirty; three units, lamps dirty, reflectors missing; two units, lamps dirty, reflectors very dirty; one unit, lamps very dirty, reflectors missing; one unit, lamps dirty, reflectors clean; two units, lamps dirty and blackened, reflectors dirty; nine units, lamps very dirty, reflectors very dirty. To arrive at the efficiency of maintenance for the tool room, the number of units having the given condition is multiplied by the various efficiencies of maintenance for those conditions, expressed decimally, and a weighted mean is taken:

12 x 0.8 x 0.8	7.68
3 x 0.8 x 0.5	1.20
2 x 0.8 x 0.7	1.12
1 x 0.7 x 0.5	0.35
1 x 0.8	0.80
2 x 0.8 x 0.8 x 0.8	1.02
9 x 0.7 x 0.7	4.41
30	16.58

$(16.58 \times 100) \div 30 = 55.2$ per cent. efficiency of maintenance.

Using this method of rating the lighting equipment, the following table shows the efficiency of maintenance in the various departments.[1]

TABLE V.

Department	Overhead illumination Units per cent. efficiency	Local illumination Units per cent. efficiency	Remarks
Tool department	55.2	38.5	Overhead units 91 per cent. after cleaning.
Motor wheel assembly dept.	44.1	28.4	
Motor wheel eng. assembly dept.	78.2	33.0	Overhead units had just been cleaned.
Grinding and punch press dept.	53.7	27.5	
Drop forge die tool room	84.8	31.8	Overhead nnits had just been cleaned.
Average	63	35	

From this table it is seen that the maintenance of the overhead illumination units is almost twice as good as that of the local units, a condition one might expect. With systematic maintenance, the overhead units can be kept in reasonably good condition, but the local lamps cannot be nearly so well maintained even with reasonably frequent inspection. It will also be noted from the table that merely cleaning overhead units

markedly increased the efficiency of maintenance. Attending to other items should bring the maintenance close to 100 per cent.

Based on the foregoing test results the following recommendations are made:

(1) Install a system of general illumination from well shaded overhead lamps in the tool room.

(2) Provide for an intensity of 10 footcandles uniform illumination on the work plane.

(3) Provide illumination sufficiently diffuse to make local lamps for all ordinary purposes unnecessary.

(4) Engage services of a lighting specialist to plan lighting system for tool room, preferably the independent consulting engineer.

(5) Institute a systematic maintenance of the lighting system after it is rehabilitated.

We feel certain that if an improved lighting system complying essentially with the above general requirements is installed in this tool room, experience with it will prove conclusively to the management that improved lighting throughout the plant will pay for itself many times over in decreased accidents and increased production.

In this case the recommendations as to improvements of the artificial lighting in the tool room were carried out voluntarily by the company. Reflecto-cap units equipped with gas-filled tungsten lamps were installed and an average initial intensity of 10 footcandles provided on the horizontal work plane. The illumination is uniform and diffuse, and local lamps have been eliminated. Because of the splendid results of this trial installation, the company has embarked upon a plan of rehabilitating the entire plant, and as this involves an expense estimated to be not less than $30,000 the work is being done piecemeal, and will be spread over several years. No official pressure on the company was necessary. The trial installation itself proved that good lighting makes possible better and more production. Systematic maintenance is now a duty of the electrical department of this plant.

Other Plants Surveyed.—In a similar manner some fifty plants were surveyed during the summer of 1917. In only a few cases was as complete a survey as that made in the above metal working plant necessary. The attempt was always made to get a demonstration installation in one department, since we agreed with what every salesman knows, namely, that a demonstration, if properly carried out, is the best method of convincing an em-

ployer of the value of better illumination. It will be remembered that at this time the old 1913 Shop Lighting Orders were still in effect, and this code gave small opportunity to get really effective illumination by order. We were, therefore, compelled to work as the salesman does, thus securing voluntary improvements. After all, this is the most effective method, orders or no orders, authority or no authority, and it is a poor inspector who gives as his reason for an order "the law requires this," and then proceeds to use coercive measures to get compliance. However, in a few instances where the lighting was so poor as to fall below the minimum of the old 1913 Shop Lighting Orders, employers were ordered to improve the lighting and it is gratifying to state that even in these cases materially better illumination was secured than what was contemplated as the minimum requirement of the new code which was then being prepared.

Since the adoption of the new code (July 1918) we have been successful in getting the new installations up to a considerably higher standard than the code minimum. The years of educational work of this society and the lighting industry is bearing fruit. Almost never do we encounter resistance; in fact, it is rare to find an employer who will not voluntarily install better lighting than the code requires of him. The R. L. M. standard dome reflector has largely displaced the flat cone in the minds of the shop superintendents as about the right thing for factory lighting. Obviously this makes enforcement of the anti-glare rule easier, since this reflector gives a better degree of shading than the code specifies as a minimum.

As already stated, the code does not apply to existing installations until July, 1920. However, the inspectors are constantly reporting voluntary improvements where they have talked better lighting to the employers. Therefore, we are very hopeful that within the next few years factory lighting in Wisconsin will be high in standard.

Possible Future Difficulties.—What some employers consider a really drastic provision of the lighting code is the rule requiring the shading of local lamps. They realize the necessity of such shading, but from experience know how difficult it is to keep all lamps equipped with shades. The inspectors may find this mat-

ter as troublesome as keeping guards on machines in place, or getting employees to wear the goggles supplied by the employer for chipping and grinding operations. Fortunately, an employer who experiences this difficulty has the alternative of reducing the number or eliminating entirely such local lamps, a result we of the I. E. S. have been trying to attain for years.

It may also be found that emergency lighting is not really necessary where a few men are employed on lower floors where dangerous obstructions are not present and where it is reasonable to assume that the men are familiar with the location of the exits and could quickly leave the building in times of emergency. As previously stated, the commission is disposed to enforce this emergency lighting provision with considerable leniency so that if an employer considers the order requiring emergency lighting unreasonable, in his particular case, he may petition the Industrial Commission for a hearing, and the commission if it actually finds the order to be unreasonable in the particular instance would (in fact is required by law to) substitute such other order as may be just and reasonable or waive the order entirely.

As yet no requests for exemption from this order have been received by the commission, but it is too early to say that the employers are willing to abide by the order. The real test will not come until the code applies to existing installations. At that time should the number of requests for exemptions in the case of small factories be numerous, and should the commission become convinced that emergency lighting under such circumstances is not necessary for safety, it will probably be necessary to issue a general exemption in the case of very small factories, or to so modify the order that the very small factories would not come under it.

WHAT THE NEW YORK STATE INDUSTRIAL COMMISSION HAS ACCOMPLISHED TOWARD IMPROVING LIGHTING CONDITIONS IN FACTORIES AND MERCANTILE ESTABLISHMENTS.*

BY JOHN H. VOGT, CHEMICAL ENGINEER AND DIRECTOR OF DIVISION OF INDUSTRIAL HYGIENE, BUREAU OF INSPECTION, STATE OF NEW YORK; DEPARTMENT OF LABOR, N. Y. STATE INDUSTRIAL COMMISSION.

The ultimate objects of any labor laws relating to factories and mercantile establishments have for their aim the prevention of accidents, the conservation of the public's health, and the health of those persons who are obliged to work within such places.

This fact was recognized in foreign countries earlier than in this country, owing no doubt to different methods pursued in manufacturing, character of buildings in which the labor was carried on and the crowded conditions in the cities and towns of the old countries.

New York State in 1886 recognized the necessity of enacting certain laws relating to labor in factories and created during that year the positions of factory inspector and one assistant to carry into effect the provisions of that law. Massachusetts, New Jersey and Ohio were ahead of the Empire state in throwing the mantle of protection and restriction around factory workers.

We, at this convention are particularly interested in the lighting question, and therefore, without rehearsing those provisions of the labor law of New York State, which do not apply to the lighting question, I shall pass them by without reference.

Not until the year 1897 were provisions made by the State Legislature of New York to incorporate into the labor laws, relating to factories, anything requiring any part of factories to be properly lighted. During this year the law was amended and a paragraph inserted which read: "When in the opinion of the factory inspector, it is necessary that the halls leading to work-

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rooms should be properly lighted, such provisions should be carried out."

In 1899, provision was made to amend the law requiring that the halls and stairs leading to workrooms should be properly lighted and such lights should be independent of motive power of such factory.

In 1902, of eleven cases brought against factory proprietors for failure to properly light halls and stairs of factories, nine acquittals were granted and two convictions secured.

Two of the laws enacted in 1904 required that workrooms, halls and stairways in factories, shall be properly lighted, and in New York City and Buffalo a light must, if ordered by the Commissioner of Labor, be kept burning in the public hallways on each floor during working hours, except when natural light suffices.

This enactment was deemed necessary at that time in the interest of public morality and particularly affected the tenant factories filled with small workshops of clothing contractors.

In 1908 the enforcement of those provisions of the law relating to mercantile establishments in cities of the first class passed to the Commissioner of Labor. One provision relating to lighting governed the issuance, of a permit for the use of basements of mercantile establishments which must be granted for its use, but only when such a basement is properly lighted, ventilated and kept in a sanitary condition.

As a result of a serious factory fire in New York City, in March 1911, in which one hundred and forty-five employees lost their lives, a commission was created by an act of the Legislature to investigate the conditions under which manufacturing was carried on in New York State resulting, after several years of work, in nearly fifty sections being added to the law some of which relate to lighting; a section providing for the creation of an Industrial Board (whose authority now is vested in the Industrial Commission), was provided for, to whom was granted the power to make rules for carrying into effect the provisions of the law.

As a result of the activities of the code committees, numerous provisions were made in the code rules to provide means to furnish artificial light in dressing rooms for bakeries and con-

fectioneries; in dressing or emergency rooms of factories; in elevator cars at all times when necessary; for toilet rooms and sinks where all parts of the room must be easily visible during working hours and in passageways and stairways also inclined runways and stairways of foundries, to be of sufficient power to properly light these places.

The words "proper light," "sufficient light" and "adequate lighting" occurring in various sections and rules of the Industrial Code are naturally difficult of interpretation, as what might be sufficient for one would be insufficient for another.

Courts, to-day, demand to know what standards exist so as to determine whether the person or firm supposed to furnish certain devices or conditions are living up to the necessary requirements. Little doubt can exist in the minds of any one as to the results of a court action if it can be proven that the intensities of light furnished in a factory falls below the minimum requirements of the code.

To obtain these standards necessitated certain rules, which when completed, would be known as "Industrial Code Rules" relating to lighting of factories and mercantile establishments.

No small amount of labor was entailed on the part of the Committee and others connected with it, having this work to perform. It was desired by this Committee to know what intensities of light were being furnished at the work in numerous factory operations; in halls, stairways, passageways, toilet rooms, elevator cars, etc., throughout the state,—the report to contain the opinion of trained inspectors and the opinion of those who are obliged to work under the intensities of light provided.

To furnish this information, the Division of Industrial Hygiene of the Bureau of Inspection of the State Industrial Commission was called upon to conduct the investigation. Three members of that division, all technical men, with years of factory inspection experience, were assigned to the task. In addition to determining the illuminating intensities provided, it was necessary that a large amount of other data be collected, among which figured the opinion of the person performing the particular factory operation; after reducing the illumination to a point at which he or she was accustomed to work, and also raising it and then getting his opinion, allowing

a reasonable amount of time to lapse for eye accommodation,—glare, character of work; distance of work from light conditions of walls; character of lights; color of material being also considered. More than 18,000 tests were conducted by these investigators during the winter months of two years, when the report was delivered in tabulation form to the Lighting Committee for their use. Without being guided or influenced by any other code, the committee adopted the standards for roadways, storage spaces, stairways, passageways and aisles from the tests made which agreed practically in its entirety to those standards set forth by the Illuminating Engineering Society.

THE CODE.

The rule relating to the minimum intensities of illumination required at floor level of roadways and yard thoroughfares, storage spaces, halls, stairs, passageways, aisles, exits, elevator entrances, toilet rooms, washrooms, dressing rooms and elevator cars, together with sections relating to shading of lamps, distribution of light and emergency lighting became mandatory July 1, 1918. As the intensity requirements of industrial operations, set forth in the appendix of the rule, do not become mandatory until July 1, 1920, manufacturers will have sufficient time to submit their criticisms and the results of their tests and their recommendations to the Bureau of Industrial Code.

SHADING OF LAMPS.

Secton "D" of rule relating to shading of lamps carries into effect Section 4, Paragraph 81 of the law which reads "Artificial illuminants in every workroom shall be installed, arranged and used so that the light furnished shall prevent unnecessary strain on the vision or glare in the eyes of the workers." This provision has been embodied in the law for several years but for lack of proper interpretation awaited the action of a rule defining more explicitly what constitutes glare and how the lights shall be arranged to prevent glare. Nothing is referred to in the law relating to glare from bright surfaces only from artificial illuminants.

Glare without question has been responsible for more eye trouble than from any other factor caused by artificial lighting. A survey recently made by the Division of Industrial Hygiene

of the Bureau of Inspection of the State Industrial Commission of New York, of Conditions under which state employees housed in sixteen buildings, including the State Capitol, all located in Albany, revealed the fact that 80 per cent. of those engaged at work wore glasses, due to poor lighting systems with improperly shaded lights.

As a compliance from an order issued to protect properly all lights in factory workrooms from glare, the inspectors accept, when lights are less than 20 ft. from the floor level, any type of a reflector which prevents the filament of the light from being seen from the ordinary line of vision. If a shallow reflector is used, the frosting of the lower end of the bulb, cutting off the view of the filament of the bulb is acceptable, also a diffuser, but in no case paper shades or other combustible substance used for shades or reflectors on account of the fire hazard presented.

Electric incandescent lights supplying general artificial illumination, located 15 ft. but not more than 20 ft. above the floor, if, of a low wattage, may be frosted and are acceptable as a compliance for the rule. But gas filled lights are not acceptable when frosted and require reflectors or diffusers to at least act as backgrounds.

DISTRIBUTION OF LIGHT.

Section "E" of the rule relating to distributing of light provides for the elimination of shadows and of excessively sharp contrasts.

A person leaving a brightly illuminated part and entering a darkened section, may, on account of the eye being slow to rapidly accommodate itself, encounter objects on the floor over which he may stumble and become injured or come in contact with the moving part of some machine, where such an accident might be a serious one. Where such conditions exist, orders to properly light these areas become necessary.

EMERGENCY LIGHTING.

When in the opinion of the Industrial Commission, emergency lighting is required, an order to provide such a system may be issued. There are a number of basements, cellars and sub-cellars used for manufacturing purposes in the state in which a large number of persons are at work. The sudden failure of the lighting system, throwing the place into darkness, might create

a panic as severe as any fire and without some guidance out of such places, it would become a difficult problem from which to find egress. In order to incur as little expense as possible, yet provide for a sufficient intensity of light a minimum of 0.25 foot-candle is required by the code corresponding to the amount required for storage spaces, stairs, halls, passageways, exits and elevator entrances. Gas lights when properly placed would suffice as a compliance with this part of the rule when electric lighting is used for general lighting.

THE FACTORY INSPECTOR.

The factory inspector to whom is assigned the enforcement of the law is the one whose judgment must be relied on to carry into effect its provisions. Prior to the adoption of the rule relating to lighting, now a part of the industrial code, the inspector could go no further than the use of his own judgment in concluding whether or not a factory workroom, a stairway, hall or toilet room was properly or sufficiently lighted. For several years it has been the policy of the department to compel the inspectors of the various supervising districts of the state to attend lectures upon subjects relating to the law. At each of these lectures were shown numerous slides illustrating conditions as they should be in accordance with the law, and rules of the industrial code which are in effect as law. In contradistinction, slides were shown illustrating conditions which were violations of the law.

Relating to lighting, several lectures were given illustrated with lantern slides whereby numerous conditions were shown, such as types of reflectors and diffusers, slides showing arrangements of lights in which shadows caused by machine and material were dissolved; effects produced with lighting systems when ceilings of the factory workrooms were painted a white color, also same lighting system with ceilings without being so painted; numerous illustrations showing the effect produced by glare and where employees were at work with bare lamps of high wattage situated directly in front of their faces, and many other illustrations.

Instructions were given the inspectors when the code rule went into effect that whenever an inspector has occasion to believe that the intensities of light were insufficient at the various

places enumerated in the code rule affecting factories or mercantile establishments, they should request that a series of tests be made by the Division of Industrial Hygiene, of the Bureau of Inspection. If it was found that the intensities fell below those required by the code rule, the inspector was sustained and he was notified that an order remedying the condition should be placed.

A recapitulation of orders issued and compliances secured by the Inspection Bureau during the past fiscal year from July 1, 1918, to July 1, 1919, shows that in the Mercantile Bureau 17 orders were issued to protect lights from glare, with 14 compliances secured while 3 were pending; 140 orders were issued to provide means for lighting various areas, toilet and wash rooms with 119 compliances secured, 14 orders pending and 9 waivals granted.

In the Division of Factory Inspection there were issued relating to lighting 7,427 orders. Of these 6,547 related to protecting lights from glare. Eight hundred and eighty related to lighting to prevent accidents. There were secured 5,644 compliances from orders to protect lights from glare and 864 compliances from orders to provide and maintain means for lighting to prevent accidents, leaving 919 orders to be complied at the close of the fiscal year. In relation to these orders there were 151 prosecutions brought by the legal division for failure to comply with the orders issued.

There still remains a great deal of work to be done to bring up factory lighting to the code rule standard. A good start has been made and the Industrial Commission will not rest until this important feature of factory inspection has been thoroughly accomplished.

STATUS OF THE INDUSTRIAL LIGHTING CODE IN NEW JERSEY.*

BY ROWLAND H. LEVERIDGE, CHIEF BUREAU OF ELECTRICAL AND MECHANICAL EQUIPMENT, DEPARTMENT OF LABOR, STATE OF NEW JERSEY.

Among the lay public there is a prevalence of opinion that there are far too many laws and ordinances for the good of all concerned. A few good laws well enforced are to be desired rather than a multiplicity of enactments which are allowed to become dead letters.

Some legislation, although excellent for the community, for various reasons is difficult of enforcement. While the state may have sufficient police power to require compliance yet it is often physically impossible to make adequate inspections and insure full compliance. In such instances co-operation on the part of the public is essential if progress is to be made. Ofttimes better results can be obtained through a policy of altruism rather than through force. Such is the case in hand at the present time.

We realized at the outset that our means of enforcement of the code was somewhat limited and that for a period educational methods should be paramount. Such a policy has been and is now being followed.

Education of State Inspectors.—In the first place the inspectors themselves who have many other regulations to enforce were not by any means lighting experts. When the code was adopted, the majority of the Departments' inspectors had given little or no attention to lighting, and were not in a position to identify poor lighting practice. The first step was, therefore, to educate our own organization.

In June 1918 we co-operated with the Department of Labor of the State of Pennsylvania in connection with a course of instruction in Industrial Lighting for state factory inspectors given by the University of Pennsylvania in Philadelphia. This work was reported in the *Electrical World* on July 6, 1918. The work of instruction, as planned by Prof. C. E. Clewell of the university

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in conjunction with representatives of the two state departments, consisted of two all-day sessions with instruction periods, both in the morning and afternoon of each day. The inspection forces of the entire State of New Jersey and those from Pennsylvania met in the Engineering Building of the Towne Scientific School. In addition to the inspectors themselves there were several representatives of the Illuminating Engineering Society. Among the general subjects discussed were the following:—

Developments of Factory Lighting Codes by Mr. G. H. Stickney.[1]
The Specifications of the Quantity of Light by Prof. C. E. Clewell.
The Relation of Glare to Factory Lighting by Prof. C. E. Clewell.
The Distribution of Light in Factory Spaces by Prof. C. E. Clewell.
Use of Gas in Factory Lighting by Mr. R. ff. Pierce.
Safety Lamps in Factory Lighting by Mr. Helms.

Dr. Sharp, the inventor, gave an illustrated lecture on:

The Use of the Footcandle Meter for Measuring Illumination.

In addition to the oral demonstrations there were exhibits of gas and electric lighting appliances arranged under the direction of Mr. G. B. Regar of the Philadelphia Electric Company. The technical lectures were looked upon more as a series of coaching lessons rather than formal lectures. Ample opportunity was given between sessions to study the exhibits in detail under the guidance of special representatives assigned to this duty. The lectures were accompanied by lantern slides showing various aspects of well designed factory lighting and attention was called to books, pamphlets and bulletins dealing with the shop lighting problem.

This course of instruction was fundamental and instilled in the representatives an appreciation of the importance of good factory lighting from the standpoint of accident prevention, eye protection as well as economy. It is believed that the inspectors went away from this course with a greater appreciation of the importance of the subject than they had ever experienced before and as a result of this introduction they were enabled to approach plant managements with enthusiasm and confidence in the work they had in hand.

Education of Electrical Contractors.—The next step was self evident; that was to insure that the men who actually have a great

[1] See *Electrical World*, July 6, 1918.

deal of influence as to the type of lighting installed were familiar with the intent and provisions of the code. They are the electrical contractors.

At the annual meeting of the New Jersey Association of Electrical Contractors and Dealers, held in Trenton January 25, 1919, the writer gave them a talk on factory lighting[2] in which the code of lighting was discussed in considerable detail. A brief outline was presented of the conditions which lead to the development of the code, and that was followed by a discussion of the factors which make compliance with its provisions a most desirable economy for the manufacturer himself. It was pointed out that the code of lighting could be enforced with minimum friction only after a campaign of education and publicity. To quote "You are the people in direct contact with the installation. You can sell poor lighting or you can sell good lighting. Through you the manufacturer can be informed on the requirements of the code, on the methods of meeting these requirements and on the general advantages accruing from the adequate artificial illumination systems. The first step, therefore, is to become thoroughly familiar with the code yourself, with its intent or purpose, with each requirement and with the means of meeting these requirements, then you are in a position to preach the doctrine of better industrial lighting. Incidentally, this, of course, means money in your own pocket."

The code was then reviewed section by section, the various rules analyzed and pertinent suggestions made as to the methods of meeting the requirements. The footcandle meter was demonstrated, the advantages of reflectors were pointed out and some data presented on the importance of frequent and periodic cleaning. Brief mention was made of the desirability of light colored surroundings and the economic features of frequent painting were called to their attention. In closing, the contractors themselves were urged to occasionally visit the installation after they had made it and the following simile was used to bring this forcibly to their attention:—

"If you sell a man a motor you would usually give him an instruction card telling him how to oil the motor, adjust the brushes and the like. If you did not do this and he did not attend to the

[2] Reprinted in the *Electrical Contractor Dealer*, March, [illegible]

matter through his own appreciation of the subject the motor would soon stall, burn out and you would be justly blamed. On the other hand, many a lighting installation is sold with no instructions or suggestions as to its maintenance******, a lighting system demands careful maintenance. If it does not receive it soon the intensity will drop so low that the men can not see to perform their work. You will get the blame. You will be told that the installation you designed and installed is not adequate to the purpose. Your engineering judgment will be criticized."

Since this time various local meetings of contractors and dealers have been addressed by different engineers on the subject of factory lighting and in each case the New Jersey Code has been discussed and analyzed. This work will be continued in the future as we realize that by constant hammering away on the subject eventually this group of men will be brought to a full realization of the importance of the question and be eager to co-operate with us in seeing that New Jersey as a whole is well illuminated.

Relation of the Public Utility Companies.—The public utilities companies throughout the State through their engineering departments, have for a considerable time been supervising and acting as consulting engineers for new building construction and have done much good work in furthering better lighting. They as well as the Contractors Association have lent themselves very readily to the application of the code and the new industrial plants show a very decided improvement in lighting conditions. As soon as our facilities permit the collection of accurate data we hope to show increased production, a reduction in accident rate and a marked improvement in workmanship in these modernly illuminated shops.

Education of the Electrical Dealer.—We recognize that the contractors and public utilities companies do not come in close contact with many of the smaller and older installations. Some method must be obtained for meeting these conditions. The attention of the small manufacturer is brought to the subject of lighting on only rare occasions, one of these being at the time when he purchases electric lamps and supplies. The agent for incandescent lamps is, therefore, in a position to do considerable

missionary work. Through the co-operation of one of the largest incandescent lamp manufacturers copies of the code of industrial lighting have been placed in the hands of all their agents and dealers in the state. The lamp manufacturer has supplemented the code with a circular letter, pointing out to the agent some of the essential features and endeavoring to educate him. It is hoped that through this means he will in turn educate the small manufacturer, calling his attention to the code and giving him some good advice as to how its provisions can best be met.

Education of the Manufacturer.—All of the steps outlined to date have treated the education of the source itself, as one might say. It is, of course, necessary to get into direct touch with the factory management and see that they become well posted on the code. Our program includes the delivery of sectional lectures to the factory management and factory chiefs representing such management and some meetings along this line have already been held. The representatives of the Illuminating Engineering Society have co-operated with us at these meetings and have stood ready to furnish speakers, lantern slides, and the like.

Museum of Industrial Safety.—Our most important proposition at the present time is the establishment of a bureau of industrial information and museum of safety. This will include physical exhibits of actual factory lighting equipment in its several forms arranged as a guide in this class of work. A building has already been secured in Jersey City, the lighting equipment has been laid out under the guidance of experts and is about to be installed.

All available information pertaining to the types of lighting equipment, both as to lamps and reflectors, spacing distance, mounting heights of units, class of work performed under the lighting, average intensity in footcandles, watts per square foot of floor area and the special features accomplished by the particular systems as applying to all industries will be available in chart and illustrations. We believe this information when considered in connection with the actual exhibit of as many phases of factory lighting as it is possible to properly display in our museum will do more to further good lighting through its educational value than any other movement at this time. The work in question is

well under way and at the time this paper is written we anticipate that the building will be ready for inspection within a few weeks. Owing to lack of funds we are indebted to the liberality of the Contractor-Dealers Association of New Jersey, the insurance carriers who are vitally interested in factory betterment, and the cordial co-operation of lamp and reflector manufacturers, for the equipment, and installation.

Summary.—Our experience with plant managements in furthering the better lighting movement indicates that they welcome the introduction of the code as they realize that it permits more efficient operation of the plant. We anticipate no trouble in securing the desired results in this class. There is, however, a more or less thoughtless element in all industries which would require in some cases a close application of the educational program and in others coercive measures to bring about the desired improvements.

Our program includes all measures necessary to accomplish the end in view, that is, the proper protection and conservation of the life, limb and eyesight of the worker as well as improvements in production and accuracy in workmanship.

At the present time sufficient appropriations are not available to make as effective progress as we desire. This does not mean that a reasonable advance in better lighting has not been realized under the code, but is intended to show that where every industry and individual manufacturing establishment would be effectively reached by our administrative program and would be required to correct poor lighting conditions, we have not been able to do more than secure compliance with its terms in connection with new building work, together with a limited advance in the older buildings through the activities of our electrical bureau which has devoted all the time possible to this work consistent with its previously established responsibilities. The progress that has been made is fully commensurate with the means we have had at hand for the administration of the code in question and hope at the next convention of the society to be able to report far greater progress with this work and to submit data on the relationship of accident prevention, increased production and more accurate work through improved lighting conditions.

Conclusion.—These educational methods are beginning to show appreciable effect, and will undoubtedly result in considerable improvement in the industrial lighting throughout the state.

It is realized however, that inspection on a large scale is necessary to reach short sighted manufacturers, who do not respond to educational methods. To carry on such inspections adequately a much larger inspection force is necessary. Requests for such assistance, thus far, have not met with success. Until such enlargement is authorized, the New Jersey Department, through its electrical bureau, will be unable to handle the Industrial Lighting Code in a really effective manner.

THE ENFORCEMENT OF THE LIGHTING CODE IN THE STATE OF PENNSYLVANIA.

JOHN S. SPICER, CHEMICAL ENGINEER, DIVISION OF INDUSTRIAL HYGIENE AND ENGINEERING. PENNA. DEPARTMENT OF LABOR AND INDUSTRY.

For the past five years the Pennsylvania Department of Labor and Industry has not only been endeavoring to have the industrial plants in the state improve their lighting systems whenever deficient or to install new ones, but also in cases where artificial illumination is not necessary to make such arrangements in their plants with regard to the sources of natural light so that all workers might be afforded adequate light for the particular work in which they are engaged.

As you are aware investigations proved that illumination was in the past a subject which was given very little, if any attention. Close study of the sources and intensity of light with respect to the position of the employees' work were not even considered in most cases, but on the contrary, the thought uppermost in the minds of those who were trying to increase output was whether there was enough room for an operation in order that each employee might have sufficient space to fabricate and to store, the unfinished and finished product.

Many fatal and serious accidents which occurred as a result of insufficient lighting in dangerous places were possibly the first things which caused employers to give consideration to the importance of adequate lighting. The efficiency engineer at the same time began to point out the necessity of proper illumination in order that the worker might not be fatigued to such an extent that production would be lessoned more than could be expected as a normal result of his mere physical labor.

It was during this time that the Pennsylvania Department of Labor and Industry was making efforts to have the general illumination of plants improved. This endeavor might be described as an effort to enforce Section 1, of our present Lighting Code. Of course, such a Code was not in existence at that time, and the only way in which the managements of plants could be interested, was to point out to them the fact that good illumi-

nation might prevent serious and fatal accidents such as those which had occurred in other plants as a result of similar conditions.

The subjects considered in our present code under Section 3, regarding the shading of lamps, and Section 4, regarding the distribution of light on work, were also given consideration by our inspectors wherever the condition was so evident that it could not escape their attention. In this event when it was necessary to call them to the attention of the plant managers they, in almost all cases, were willing to make the recommended changes.

The great problem, however, in all this pioneer work was the question as to what constituted adequate light. Discussions upon this subject were frequent as each individual had a different opinion and, until the appearance of the Code, a satisfactory answer could not be given. Since its adoption this source of trouble has been removed, and all our supervising inspectors have reported to me that employers not only accept the Lighting Code as an authoritative standard but are also showing considerable interest in the general subject of lighting and welcome any suggestions which are offered along this line.

Inasmuch as the Department feels that the enforcement of the Code should be obtained by educational methods rather than by the mandatory power of the law this interest is very gratifying, and it insures willing compliance in practically all cases where a deficiency is pointed out.

One of our inspectors as a result of a two day visit on inspection work in a certain locality of our state sent in the following report on the subject of the Lighting Code with respect to some of the plants he visited at that time. It is only typical of similar reports which are continually being received. He says, "I have introduced the Lighting Code to Mr. Blank, Superintendent of the Blank Hosiery Company, who desires to change lighting system or at least have the present one improved. The Shop Superintendent of the Railroad Repair Shops was glad to know of the Code and wishes a copy of the same. Mr.———, Superintendent of the ——— Knitting Mill, who is to install electric lights in their new building was pleased to know of the Lighting

Code, and wishes us to come when the lights are to be installed and assist him in their location. Please have the copy of the Lighting Code mailed to each of these men. These superintendents promised to write me when they are ready for the changes, and I have promised each of them the Department's assistance with the use of the foot-candle meter."

Another report from an inspector, from a different section of the state also illustrates in a general way how our educational work of presenting the Code to the individual manufacturer is succeeding. He writes, "The following is my report and results found by me on July 1st at ——— Silk Company. They were installing a new wiring system in the weaving, warping and binding department and after taking several readings with the foot-candle meter after darkness I found in the weaving department that the globes were too large and hanging too low, which was to the satisfaction of the master mechanic clearly shown, by raising the lamps about 4 feet higher and placing a smaller candle power globe in place of the larger one. The lighting in the winding and twisting department, also shows good readings with the exception of one set of frames, which are going to receive their attention. This firm wants good lighting results and is willing to go along and abide by the State Lighting Code. This mill has been poorly lighted heretofore and shows it in a couple of places. The General Manager and Master Mechanic were interestd in the reading of the foot-candle meter and I am sure they are sincere in their efforts to light this mill well."

As these reports are typical ones I feel you can agree with me that the Code is meeting a most favorable reception at the hands of managements of our industries. I am informed too by our inspectors that labor has been especially pleased with the progress that has been made in our Pennsylvania plants along lighting lines. This is particularly true in the case of foundries where an especial effort has been made to see that the requirements of the Code are lived up to. As a result it is universally agreed that the lighting in the foundries of Pennsylvania has been increased many fold. This improvement was partly due to the installation of new systems of artificial illumination and partly as a result of window cleaning or the installation of additional windows to provide increased natural light.

As an instance to show the change which has come about in our industrial world in Pennsylvania today I might say that frequently we are called upon to investigate complaints to the effect that there is too much instead of too little light in a factory. An investigation of such complaints generally reveals the fact that they originate as a result of excessive glare in a workroom. Not long since one of our inspectors in going through a most modernly equipped factory employing over 800 persons found that, owing to the isolated and commanding positions of the factory's location with reference to the surrounding buildings and landscape, it had as a result of the large window area, a very perceptible glare in all the workrooms. The surrounding landscape was below the horizontal line of vision as the employees faced the windows and consequently the only thing visible was the intense light coming from above the sky line. Experiments now are being made with an idea of trying to find out whether it will be best in this particular case to place shades over the windows, or install rib or prism glass in these windows. In another instance an indirect lighting system had been installed in a small knitting mill. The walls and ceiling of the workroom were white, but the manager complained to our regular district inspector that he did not find the system satisfactory and expected to make changes. The inspector stated that he believed the Department would be able to help him and to that end offered to take the matter up with our Harrisburg office, if he so desired. The manager stated he would be extremely pleased to have the assistance offered and as a result his plant was visited, calculations made and it was found out that instead of using 300 watt lamps, if he should install 400 watt lamps his difficulty would be overcome.

Those of you who have traveled over the Pennsylvania Railroad from Pittsburgh to Philadelphia and have observed the various manufacturing plants clustering along its line, could not help being impressed with the changes in the lighting of these plants during the last five years. Five years ago about the only thing noticeable at night would be flaming smoke stacks. Now, however, the twinkle of the innumerable lights about the various plants causes them to show up like amusement parks with their myriad of lights.

I do not intend to convey to you the impression that all establishments in Pennsylvania have complied with the Code. Such is not the case but it can truthfully be said that material progress has been made particularly by those establishments who are large enough and progressive enough to do things as the result of such a stimulus as the issuance of a Lighting Code.

One of such establishments which I recently visited with reference to the Lighting Code informed me that their new installation of hundreds of madza lamps of from 100 to 400 watts capacity had not only proved most satisfactory but was actually costing them less money for maintenance. The arc lights which this system replaced did not give nearly the amount of light required and "were eating up a bunch of current" as the mechanic expressed it. The new system had proven most satisfactory and was particularly economical because the switches were so arranged that lamps need only be turned on as needed *i. e.* those nearest to the windows were turned on last, as natural illumination failed during the close of the day.

Our present method of establishing better lighting throughout the state is based on the following procedure: The state is divided into six major districts, presided over by a supervising inspector. Under each supervising inspector are numerable local inspectors, the number being governed entirely by the number of establishments in the particular district. Attached to each supervisor's office is an inspector who has been given special instruction with reference to the enforcement of the Lighting Code. Cases where deficient lighting apparently exists are referred to the supervising inspector by the various local inspectors, as these cases come to their attention while making their routine inspections. These cases are then referred in turn to the special inspector trained to handle such cases, and in the event of his being unable to satisfactorily terminate the the case it is referred to the Harrisburg office for the consideration of the Division of Industrial Hygiene and Engineering.

In conclusion I would state that the Code in its main features has proven practical and has been instrumental in influencing better industrial lighting in our State. It will however take considerable time before it will be possible to state that every plant has complied with it in its entirety.

FEDERAL RULES FOR INDUSTRIAL LIGHTING AND EYE PROTECTION.*

By M. G. Lloyd

BUREAU OF STANDARDS, WASHINGTON, D. C.

During the war the safety engineers of the Federal Navy Yards and Arsenals, with the cooperation of the Bureau of Standards, formulated a series of safety standards intended to prevent accidents and protect the workers of the Federal industrial establishments along the lines of safety and sanitation.

Among the codes thus prepared was one dealing with building construction which included requirements for both daylight and artificial illumination, and another dealing with head and eye protection which contained requirements for the protection of the eye from both mechanical hazards and excessive light intensities in such work as acetylene and electric welding.

The paragraphs covering illumination in the Standards for Building Construction were modeled after the Industrial Lighting Code of the Illuminating Engineering Society, but contained slight variations from it. They differ also from the more recent state enactments such as the Industrial Code of New York State.

Intensities Required.—Artificial lighting of the stated intensities is required whenever natural light falls below double the minimum intensities for the artificial lighting. These specified intensities are in general the same as the other codes although the minimum for foundry work and rough machine work is set at 1.25 foot-candles.

Glare.—Glare is ruled out, whether it arises from exposed lamps, from direct sun light, or from unduly bright reflecting surfaces.

Elevator Landings.—A special provision requires adequate lighting of the landing threshold and the floor of elevator cars.

Emergency Lighting.—The necessity for emergency lighting is restricted to such cases "where conditions require it," and such lighting is not required to be concurrently in operation with the

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regular lighting if it is arranged to be automatically lighted when the regular system fails.

Accessibility.—The artificial lighting equipment must be so installed as to be readily accessible for cleaning and both this equipment and the windows must be periodically cleaned.

Eye Protection.—The Standard for Eye Protection recognizes 5 groups of operations in which protection is required. Group A includes such work as chipping and riveting. Group B includes grinding, dipping and similar operations. Group C includes sand blasting. All three of these groups require mechanical protection, and specifications are given providing for adequate strength of goggle frames, and of the glass lens used with them.

Group D includes furnace work and oxy-acetylene welding. Group E includes electric arc welding. Groups D and E involve optical protection of the eye and specifications for the transmission of the glass used are included.

The Code for Eye Protection has since been further elaborated by the Bureau of Standards for general use and now recognizes four additional groups of operations. One of these includes automobile and locomotive driving. Another covers operations like babitting where molten metal may be splashed. Another covers protection from fumes and gases as in chemical operations, and still another, exposure to excessive glare from such sources as snow-covered ground, lamps, etc.

Enforcement.—The Federal Safety Standards were completed only a few months before the armistice and had not yet been promulgated by official orders at that time. After the armistice interest in the subject on the part of the higher officials of the Government seemed to dwindle and the necessity for economy resulted in the displacement of many of the safety engineers who had previously been attached to the Federal plants. Even where a safety official was retained, changes in personnel were numerous with the consequent discontinuity in the attention given to the Safety Standards.

In spite of these obstacles and discouragements to the application of the Federal Safety Standards, they have been widely applied and have resulted in a distinct improvement in safety conditions in many of the Federal plants. Building construction,

however, has usually been a rush job and the attention to illumination requirements has not been all that could be desired. In some of the new buildings erected by the Government no attention has been paid to the illumination requirements of the Safety Standards but in other cases they have been followed and satisfactory results have been obtained. Where departures from the requirements are found it has not been due to any attempt to cut down expense but rather to mere neglect to ascertain the requirements on the part of busy officials.

There is also a general lack of equipment such as photometers and illuminometers for determining whether the actual intensities of light provided at the working plane are equal to those specified in the rules. However, in most of the Federal plants there is not much question as to intensities reaching the minimum values specified.

Arsenals.—At the Springfield Armory, Springfield, Mass., a system of general illumination from overhead sources was adopted and localized lighting eliminated except where it was considered necessary on account of the peculiar nature of the work to be performed. A substantially uniform distribution was obtained by properly spacing the units which were equipped with porcelain-enamelled steel reflectors giving a wide distribution. This reflector has a cut-off angle sufficient to avoid glare and is of a type which is easily kept clean. The wattage used was approximately $\frac{3}{4}$ of a watt per square foot in those parts of the shop where higher illumination intensities were needed.

Another type of installation which was used consisted of 300-watt, 20-ampere series lamps enclosed in a carrara glass globe using "novalux" fixtures. This installation gave uniform distribution without glare and with low intrinsic brilliancy. Localized lighting was provided at individual machines and benches where the working plane was not satisfactorily lighted by the general overhead system. This was sometimes accomplished by drop cords and at other times by using rigid or flexible arm brackets. In all cases 15-watt lamps were used with porcelain-enamelled steel reflectors arranged to avoid glare.

Two new buildings at the Watervliet Arsenal, Watervliet, N. Y., are arranged with saw-tooth roofs containing ribbed fac-

tory glass in the windows of the roof, sides and ends, which gives nearly uniform day light illumination.

A new breech mechanism shop is also supplied with the ribbed factory glass on the sides and ends and has a white ceiling. At first it was found that this arrangement supplied too much light and glare. The glass on the sides of the building exposed to the direct rays of the sun was treated with a light coat of cold water paint having a slight greenish tinge. This remedied the extreme glare and gave a pleasing effect. The accumulation of dust on the outside of the glass also contributed to the lessening of the glare.

The artificial light unfortunately does not comply with the standards, as exposed lamps have been installed which produce considerable glare. Night work, however, is not carried on in this building at the present time, but when constructed there was a demand for such work, and such fixtures were installed as could be immediately secured at the time.

Navy Yards.—In most of the Navy Yards sufficient intensities of illumination are provided by both daylight and artificial light, but the requirements have not always been met in other directions. At the Philadelphia Navy Yard the drop lights over the work benches in the joiner shop have been done away with and the general illumination increased, using ceiling lamps with suitable reflectors. The old machine shop is still equipped with individual drop lamps over the machines, but they are equipped with reflectors to prevent glare in the operator's eyes.

Here, as in the breech-mechanism shop at Watervliet, it was found necessary to paint the sky light of the pattern shop and the side windows of the new air craft factory to eliminate day light glare. In this case the paint was given a yellowish tinge.

The illumination of the Navy Yard at Puget Sound has been rearranged and alterations costing about $20,000 just completed. This installation has been made to conform completely to the requirements of the Federal Code.

At the Portsmouth Navy Yard considerable progress has been made in conforming to the standards. As in other cases, the sun light through the windows has been found to produce glare and steps are being taken to correct this. In some cases window

Fig. 1.

Fig. 2.

shades and awnings have been provided. Measurements made in one of the large buildings recently finished showed that on a cloudy day the natural illumination produced 22 foot-candles and the artificial lighting in the same building showed an average of 3.15 foot-candles. This building has walls which are almost completely of glass as shown by the outside view in Figure 1. The interior is shown in Figure 2 where it will be seen that fairly uniform illumination is provided by the overhead units which were suspended high enough to clear the traveling crane.

The above is a somewhat fragmentary exposition of conditions which indicate that full compliance with the Federal Standards has not yet been secured, but efforts are being consistently made by the safety engineers to secure better results and it may be anticipated that conditions will gradually be brought into conformity with the requirements.

In conclusion, I wish to express my thanks to the following engineers for their assistance in compiling this information:

John R. Hugelman, Safety Engr., Portsmouth Navy Yard.
Alfred W. Jansen, Safety Engr., New York Navy Yard.
O. J. Smith, Safety Engr., Philadelphia Navy Yard.
D. B. Heilman, Safety Engr., Norfolk Navy Yard.
C. Paul Bates, Safety Engr., Puget Sound Navy Yard.
G. W. Atkinson, Elec. Engr., Springfield Armory.
Clinton R. Tallcot, Supt. of Safety Dept., Watervliet Arsenal.

THE INSURANCE COMPANY INSPECTOR AND THE LIGHTING CODES.*

BY R. E. SIMPSON.

The Industrial Commission, or the Labor Department functioning in each state of the Union has for its primary purpose the supervision of the welfare of the workers. To assist these bodies in the fulfilment of their duties certain legislative enactments have been passed, and with the authority thus granted to them, the commissioners have devised rules, regulations, and codes for the guidance of employer and employee. Among the last mentioned is the code for the lighting of workplaces, which has been promulgated with the idea of eventually eliminating or at least minimizing injuries due to improper or inadequate illumination.

Insurance companies writing compensation, liability, and accident insurance are very much interested in the practical effect of these codes in reducing the accident rate, for several reasons. First and foremost, the elimination of accidents prevents human suffering and sacrifice; second, the insurance carriers have fewer compensation claims to account for; and third, the benefits thus obtained are shared with the assured, for under the system of experience rating a favorable accident history is reflected by a saving in the insurance premium.

In order to get an indication of the working of the code on lighting, The Travelers Insurance Company instructed its inspectors in the States of New York, New Jersey, and Pennsylvania to take note of the lighting conditions of the factories and other workplaces inspected, and make definite inquiries of the executives on the accident rate and production rate. Several hundred reports were returned and from these certain inferences may be drawn, although the survey so far has not been broad enough in point of time or area covered to form definite conclusions.

A fact fairly well established is the willingness of factory managers to comply with the code whenever their attention was directed to the necessity for action. Approximately 90 per

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cent. of the factories visited by our inspectors have lighting conditions that fulfil the requirements of the code so far as working spaces are concerned. The remaining 10 per cent. either have insufficient illumination, poor distribution of the light, or unshaded lamps. About half the plants are open to the criticism of inadequately lighted stairways, passageways, storage spaces, and yards. The familiar drop-light without reflector, or with a makeshift reflector, was frequently noted in the reports. In two instances our inspectors criticized the overhead lighting system because of the use of Mazda C lamps with shallow reflectors and low head-room. This indicates that the inspectors take note of the more common faults of industrial lighting installations.

A large percentage of the factories inspected had been visited by state inspectors and the lighting conditions had been approved, or orders given for improvement. An exception to this statement may be noted for in the western and southwestern part of New York nearly all the factory executives professed no knowledge of the lighting code. Of the many hundred reports sent in there was only one instance in which The Travelers Insurance Company inspector judged the lighting conditions inadequate after the state inspector had given his approval.

Our reports indicate that the adoption and enforcement of the lighting code has had a beneficial influence on the accident rate. In no instance in the factories inspected was there an accident which the executives judged could be chargeable to inadequate lighting facilities. In a few cases there was a difference of opinion, while in several others the lighting conditions were such that the hazard was increased, although no accidents had occurred. Attention was directed to the probability of accidents on stairways and in passageways having little or no illumination. Plant managers have a tendency to attribute accidents at these points to carelessness, crowding, and pushing. Undoubtedly there is generally undue crowding, pushing, and hurrying, especially at quitting time, and this conduct increases the hazard. It cannot be denied, however, that inadequate or improper lighting still further increases the hazard.

From the data so far presented by the insurance companies' inspectors we may fairly assume that the enforcement of the lighting code will promote the welfare and safety of workmen.

We may also assume that greater attention must be given to reflector equipment, especially on drop-lights, and to the lighting of stairways, passageways, and other unfrequented places. The burden of criticism is centered on these points and apparently a great deal of educational missionary work must be done before the full benefit of the lighting codes will be realized.

DISCUSSIONS PRESENTED AT CHICAGO CONVENTION.

J. A. HOEVELER: In Wisconsin, since the lighting code was adopted, the state has made industrial diseases compensatable, the same as industrial accidents and therefore the importance of the code is increased, I believe. It is possible that cases will arise where men will claim loss of vision due to bad lighting in employment, and claim compensation.

F. C. CALDWELL. The preparation of the Ohio code was begun early but its completion has been long delayed chiefly by the thoroughness with which safety code making is carried on in Ohio. To show how carefully this is done it may be mentioned that there have been eight public hearings in six cities, each occupying the better part of a day. These have not been formalities, and the Ohio code is much better, especially in the matter of being more workable because of the points that have been brought out in these meetings. If more of our laws could be constructed as carefully as these safety codes we would have less trouble in their enforcement. There have been three different revisions of the code. The work is now completed so far as the committee that is drawing it up is concerned. It is up to the commission and it will probably be acted upon in the near future.

The Ohio code, like that of New York, has provided a table of intensities for the various industries of the state. It is realized that these figures are not perfect, but the imperfect judgment of a group of illuminating engineers is to be preferred to the imperfect judgment of a rather inexperienced factory inspector. This table is given in the appendix, as it is not felt that it has the weight that warrants putting it into the code itself. It is to be regarded only as a guide to the inspectors and others who have to do with the law.

In Ohio, also, the manufacturers have been asked to contribute data on light intensities needed. Very valuable assistance

was given by the rubber industries of the state. The intensities which they decided upon after much investigation, formed the basis of the code specifications for this industry. On the other hand figures furnished by another large industry, were regarded by the committee as for the most part too low.

There are two noteworthy variations of the Ohio code from the I. E. S. code. One is a clause relieving the manufacturer from the requirements of the code in the case of accidental temporary reduction of light. The other is a provision for a 15% tolerance, "to take into account degree of precision in measurement." Detailed instruction for the avoidance of glare are not included in the code proper, but suggestions following closely the provisions of the Wisconsin code are included in the appendix.

Some legal opposition has been encountered on account of the fact that in Ohio damage suits are permitted under certain circumstances, in spite of the workmen's compensation law. Some fear has been expressed that the lighting code might offer another handle for the unscrupulous attorney.

We have all noticed the strong educational element that has permeated all of these reports. In other words, the educational aspect of this work is the main thing at present. The legal side of it, the enforcement by law, is thus far of very minor importance; New York seems to be the only state that has even made a beginning. There is one phase which is of interest in comparing this with other codes. Most safety codes are effective only through legal enforcement; because the man who wishes to treat his employes humanely, is in competition with the man who will do the right and just thing only under compulsion. Now the lighting code has a great advantage in that compliance with it is not a matter of expense but of profit to the manufacturer.

The absence of opposition which has been noted throughout all of these papers, and the willingness on the part of the manufacturers to comply with the codes, and, where they are progressive, to go far beyond the minimum requirements, is most satisfactory.

LOUIS BELL: For Massachusetts we can report material progress, although no code has yet been put in force. The matter was brought up to the very sympathetic and interested

commissioner of labor and industry there, the Honorable Edwin Mulready, and the state of Massachusetts, in brief, through its commissioner of labor is thoroughly interested in getting the code started. I had several interviews with the board and I found them altogether interested. I was enabled to get for a brief day of instruction, the whole body of factory inspectors. I found that they were thoroughly sympathetic and particular interest was expressed in the demonstrations which we had as to the ease of seeing with various known intensities on quite a wide class of objects that we spread out on a table and lighted by suitably fitted lamps to various intensities. The inspectors were not only much interested, but were pretty keen in the matter. They were an exceptionally intelligent crowd of men and women who wanted to see something done and who will be glad to help. All of that was very encouraging and I was requested by the board to draw up a code, which I did, based very largely on the New York and I. E. S. codes with some modifications which seemed in the present state of information to be desirable. In Massachusetts that code accepted by the board has the force of law so soon as they choose to put it into force. They have a public hearing and then promulgate the code with the force of law so that the code can actually be enforced so far as any code is enforcible. Unfortunately the last session of the Massachusetts legislature passed a reorganization act which more or less rendered the affairs of all the commissions in the state up in the air for some little period and nothing substantial was done until recently. I was asked at my last interview with the board also to take up the question of daylight illumination and embody that in the code, and I am getting ready to take up that and I have great hopes that after coming back from this gathering with the stimulus of the work that is being done in other states the thing can now be taken up and pushed through. Massachusetts is thoroughly in harmony with the idea of a code, as enforcible as any code can be. The only difficulty we had was with this question of emergency lighting and I think that by limitation of areas the case can be dealt with effectively.

G. C. Keech: I believe it would be of interest to the members of the Society to know that the Illinois Manufacturers' Associa-

tion appointed two delegates to attend this session and to make a comprehensive report of the papers and discussion to be transmitted to the members of the Illinois Manufacturers' Association through its Secretary's office, and it would look as if the establishment of a code in Illinois would be started through an entirely different channel than it has been started in other states, that is, by way of a State Manufacturers' Association which, in Illinois comprises about 3,000 members. The delegates are Mr. A. R. Brunker, President of the Liquid Carbonic Company, and myself, and we hope at the next convention of the Society, there will be something further to report on Illinois.

EDW. P. HYDE: It is so seldom that an opportunity is afforded to convey any information to the members of the Illuminating Engineering Society regarding the International Commission on Illumination and the United States National Committee of this country that I had hoped to preface my remarks on this with a few words regarding the Commission, but I have already caught the cue that this will be under the ban, and I shall have to defer it until some later time. One of the activities that the National Committee undertook to do during this emergency was to prepare or have prepared a report of what had been done in this country in the way of codifying laws in regard to illumination with the thought that if this were transmitted to the national committees of allied countries, which are members of the commission, it might be of some service to them during the reconstruction period. A committee consisting of Mr. Preston S. Millar as Chairman and Mr. J. R. Cravath, have prepared a report, a copy of which I have in my hand, a fairly good sized bound volume which has already been sent to the various allied countries through the various national committees on illumination. Mr. Millar should have presented this himself because he and Mr. Cravath did all the work, but he insisted that I should do it. After an introductory statement the appendix containing the following papers is added:

The Illuminating Engineering Society Code.
The Factory Lighting Code of Pennsylvania.
The Code of New Jersey.

The Code of the Committee of the Labor Advisory Commission, Council of National Defense.
Industrial Lighting Code of Wisconsin.
Code of New York.
Legislation Enacted by the State of Oregon.
Industrial Code Proposed for the State of Ohio.
A Paper by Mr. Stickney, on the Present Status of Industrial Lighting Codes.
Reflector and Lamp Manufacturers' Standard Specifications.
The Illuminating Engineering Society Code of School Lighting.

L. B. MARKS: There are at present six states in which the codes have been enacted into law in this country. These are Pennsylvania, New Jersey, New York, Wisconsin, California and Oregon. These are not stated in the order in which the codes were adopted, but California and Oregon are more recent than the others. There are also now under consideration lighting codes in the states of Ohio, Massachusetts, Oklahoma, Utah and some ten others that are not quite as far advanced.

The difficulty in the application of these codes as I see it, is that we do not know just exactly where we are with regard to the technical foundation for some of the matter that is in the state codes. We are called upon in a state code to make a distinction between the requirements of illumination for good vision and the requirements of illumination for safety and health. Now, just where to draw the line between what you would consider safe illumination, illumination that will conserve the health of the worker, and desirable illumination, or if you choose to call it, going a step further, *productive* illumination, is a difficult matter; standards have been set by the committee, perhaps more or less elastic standards, to guide the states in this matter. The Society has taken the position through its Committee on Lighting Legislation that we are not in a position, because of a lack of authoritative data, to give the states very much more than what we have done. We are quite willing, as a Society to watch a state experiment, as at the present time is being done in the state of Wisconsin and also in New York. Then the Society having obtained the

information, the result of experience not only by the state but perhaps by some of its own members, may be in a better position at some later date to decide on more definite standards, not only as to intensity of illuminaiton but as to glare.

That brings up my second point—the question of glare and the standards for glare. We have no instrument for measuring glare. We have not the accurate information based upon laboratory tests, practical work, and extended experience that will enable us to say just what the limits of glare should be, that is, to state the limits in such terms that the factory inspector can apply them practically; and we are dependent to a very considerable extent upon the factory inspector. Therefore, the campaign that we have initiated has been one largely of educating the factory inspector who of all men craves this very education and is very quick to grasp the idea once it can be laid simply before him.

Some of these points may seem overdrawn because we all know that the average factory manager, who is interested in increasing the product and decreasing the spoilage, and making more money out of his plant, is quite willing and even anxious to improve his lighting and to conform with the reasonable requirements of the lighting code, or even with higher standards than those stipulated in the code, once it is made clear to him what these requirements are and what their purpose is. So that we have, as I see it, in the application of the industrial lighting codes an opportunity to help the factory manager, to help the community to increase production, decrease spoilage and give to the world what seems to me to be one of the most important things that the Illuminating Engineering Society can give.

Thirdly, the codes are necessarily weak in some respects as we all know, because we have not the foundation upon which to base more definite requirements and rules. The very nature of the codes takes us somewhat outside of the sphere of the Illuminating Enginering Society. I refer more particularly to the clause in the codes that relates to emergency lighting. As a society, we do not deal with the production or distribution of the electrical current or gas for producing the light. We start practically at the lighting outlet, leaving the problems up to this point to the gas associations and electrical societies. So that when it comes to a question of whether we should have a separate transformer

service for emergency lighting or whether we should have separate storage batteries or a duplicate electric light plant to provide for contingencies, that is a matter that would seem to come within the purview of other organizations, industrial boards, and safety engineers.

The state of Oregon is so far as I am aware the only state in the country that has written into the law a statement to the effect that the commission shall be guided by the best engineering practice as set forth in the recommendations of the Illuminating Engineering Society. It is a very hopeful sign indeed, that a state expresses such great confidence in the integrity and standing of our Society.

There is one other state in which a code will be in effect on December 1st, and that is California. Advance copies of the California code were printed and distributed for discussion some months ago; slight revisions have been made in the part of the code that relates to the tentative schedule of illumination intensities for detailed industrial operations.

All of these codes you will note have two sections, one relating to mandatory requirements and another, an appendix ,which gives suggestions and information to factory inspectors and others as to the methods of securing the best results in illumination. Our experience has been that in no state has the desire been to arrest anybody for breaking any law. On the contrary the desire has been to show them the right thing to do and to help them do it.

I would like to correct at this time one statement that Professor Caldwell made with reference to the intensities given in the present Ohio code and in the present New York code. I take it that he has not seen the revised code of the state of New York because there is a great disparity between the intensities given in the tables; in fact, in the New York state code, almost throughout the intensity is about half, generally speaking, of that recommended in Ohio, and in a number of cases, the intensity in the Ohio code is 400 per cent. higher than the New York code and in several others 50 per cent. lower.

F. H. Murphy: Oregon had to go at it a little differently, perhaps, from a good many states because our Indus-

trial Accident Commission had no authority to establish lighting standards in any way. It was necessary therefore to go before the legislature and get a special law granting such authority to some department body. The Bureau of Labor was the department of the state that was selected to enforce this. However, we have had the active support of the Industrial Accident Commission in working out our plans and the Labor Commission also keeps quite closely in touch with this Department at the present time. We hope it will always be the case.

In the first place, in order to get the support that we felt was needed, we took the matter up with the Oregon State Federation of Labor and they endorsed it and recommended it to one of their representatives for introduction as a bill in the Lower House. They had rather a strong representation at the legislature but it was always a problem as to who was to be really the controlling factor. However, we were fortunate in getting the employers' association also to feel kindly toward the bill and your speaking, Mr. Chairman, of the uncertainty of some of these things, reminded me of a little incident that occurred which very nearly finished all our chances for the next two years. I am employed by the Portland Railway, Light and Power Company, and the employers' legislative agent, for some reason of other, felt that our company had not given proper support to one of the bills that he was anxious to get through. It was the case of a bill in which labor and capital were at swords' points. We were not taking a very active part either way. So he picked on this particular bill for the sacrifice. Fortunately we happened to be in Salem that day and it did not take very long to persuade him that the Portland Railway had nothing to do with our bill and that the bill itself was really commendable. This saved the day for us for the employers' association was undoubtedly strong enough to put a crimp in us at that time. That incident illustrates the uncertainty that besets all legislation.

In due time we secured our bill, and one point that I would like to call to your attention is the fact that we have defined places of employment, and that that definition is a very broad one. It should also be mentioned that this definition is not original, but was taken from the Industrial Commission Law of the State of Wisconsin.

"The phrase 'place of employment' shall mean and include every place, whether indoors or out, or underground, and the premises appurtenant thereto, where either temporarily or permanently any industry, trade or business is carried on, or where any process or operation, directly or indirectly relating to any industry, trade or business is carried on, and where any person is directly or indirectly employed by another for direct or indirect gain or profit, but shall not include any place where persons are employed in private domestic service or agricultural pursuits which do not involve the use of mechanical power."

Also the term "owner" is defined in an equally broad manner. We can, with these definitions, regulate the lighting in stores and offices as well as in industrial plants if it becomes necessary. However, the first object will be industrial plants.

Our law does not establish any limiting values, either in regard to glare conditions or illumination intensities but it does establish, or rather authorizes the Labor Commissioner to appoint a Commission that has the power to recommend to this official such limiting values. That Commission has been appointed and its first report has been made. This provision of the law makes revision of these limiting values possible at any time through this Commission instead of depending upon the uncertainties and delays of Legislative enactment. The law further states that the Labor Commissioner shall be guided by the best engineering practice as set forth in the recommendations of the Illuminating Engineering Society in establishing these limiting values. It should be stated that this provision made the legislators feel more confident that no drastic ruling would be made, and that fact made it very much easier for us to get the bill through the legislature.

This Commission has made its rules, as I stated before, and we are practically ready to begin the application of the code. The limiting values are so nearly in conformity with those in force in various states at the present time that it is hardly necessary to take them up at this time. There are one or two minor changes.

We have included, for one thing, a paragraph on maintenance. That is a matter that raises a question possibly in some of your minds. While the "limiting values" would in a way require reasonable maintenance, yet we felt that by putting that provision in as a rule it would call a little more attention to the necessity for

cleaning and impress it perhaps a little better upon the managers than would be the case if it did not occur as a rule.

The attitude of the public has been very agreeable to us who have had anything to do with this code. We have found that in practically all cases we have had the support of the employers as well as of the labor organizations. The Industrial Accident Commission has already taken steps toward segregating the accidents due to lighting, either directly or indirectly, a thing which they had not done before, so that we should have some data from that source to be of assistance to us in the near future.

The Commissioner of the Bureau of Labor is a very active believer in, and supporter of, the industrial lighting code which we have adopted, and he is a man who is showing good judgment in his plans for the application of the code. This is certainly very fortunate. He tries to keep in touch with this movement and he has already laid his plans for enforcing the Code, but they are not drastic in any way. His idea is to begin by making an industrial survey, find the worst cases and start in with moral suasion and education, keeping that method up as long as it is possible to get results. After that, if it is necessary, he has an enforcement clause in Section 9 of the law that we think will make it effective.

G. B. NICHOLS: For the last five years, it has been my privilege to attend hearings on the budget and financial condition of the state. I think you would all be surprised if you could take the time to know the number of activities that are being undertaken by the state and municipal bodies all along the line. Out of the proposed activities, it is safe to say that not over 5 per cent. of them are able to be undertaken, on account of the great demands on the public finances, so that this whole question has to be placed on somewhat of a financial basis. We have a motto in New York State, "Health is purchaseable." Eyesight is also purchaseable, but are you going to pay for that item. In dealing with the question of the Code, it appears to me that the whole subject divides itself under two heads. One is the educational side that can be carried on at a minimum cost, with a small force, touching all parts of the state through popular lectures and literature. The other is, enforcing the Code by certain statutary laws. This side is going to cost a considerable sum and I very much doubt

if with the large number of state activities that the Society can convince the various legislators that state laws are necessary. The state cannot take on these expensive activities. Now I want it plainly understood that I am not discouraging the Code in the least, but it is not wise to go too fast in this work. Analyzing the discussions here this morning, I note that Wisconsin is calling upon the builder of every new building to prepare plans which are to be submitted to a state department to act upon. The preparation of these plans by the owner is going to require a considerable expenditure, all of which must be met by the taxpayer. After this expense has been met by the owner, it would be unfortunate if the plans were not examined in equal detail by a representative force employed by the state. I doubt if any of the states are in a position to undertake the examination of such an extensive lot of plans which would ensue if the outlined laws were passed. It is appalling in going over the state activities what a large number of worthy items have to be deferred on account of the cost involved and I believe this Society should definitely go on record that a propaganda of education in the matter of the Lighting Code should be carried on at a minimum cost.

J. A. Hoeveler (In reply): I am in hopes that the discussion of these papers will bring out some phases that will tell us what to do when we come to apply the Wisconsin code to existing installation. When an employer builds a new factory he usually wants to build it right, but to get the existing installations on the right basis with a force of inspectors who are not illuminating specialists, I think is going to be a problem. We would like what advice you care to offer.

DISCUSSIONS AT NEW YORK SECTION MEETING.

W. T. Blackwell: The papers read by Mr. Hoeveler and Mr. Leveridge convey a message to the electrical contractor regarding his function in the electrical trade. The superintendent of an industrial plant calls in an electrical contractor to solve his problem, which we will say is one of illumination. As a man's reputation is built upon the result of his work I am afraid that the electrical contractor has not a great deal to be proud of in his

illuminating work. The contractor knows full well that he must install his work in accordance with the provisions of the code. This code may be a Municipal Code or the National Electrical Code, but in either event he knows that he cannot obtain payment for the work done unless the equipment is installed in compliance with the code and receives the approval of the inspector. We will assume that a contractor is doing business in a state where there is a State Lighting Code. These codes are effective only when they are effectively enforced—therefore, the electrical inspectors representing the municipality or underwriters are educated to pass upon the safety of an electrical installation from a fire hazard point of view. This is being successfully accomplished and the same method of procedure must be adopted by the States in educating their inspectors to enforce the requirements of the State Lighting Code.

We will not get anywhere with these lighting codes until we bring to the realization of the electrical contractor that the work which he does establishes his reputation. In the past most of the illumination educational efforts have been directed at the industrial manager. We have appealed to him through his pocketbook, through pointing out that proper lighting produces increased production and also lessens the accident hazard.

In States where lighting codes have been adopted the officials in charge have realized that they cannot enforce their regulations unless they educate their inspectors—there has been an effort made in that direction but there is still a great deal to be done. Through the daily routine work of the inspector considerable information will be conveyed to the electrical contractor and to the industrial plant having electrical squads, bringing to their attention wherein their lighting installations do not comply with the State requirements.

Recently, in talking to an electrical contractor, I questioned him as to his knowledge of illumination and he confessed that he uses a rule of thumb method which was simply based upon a crude idea of what illumination he obtained through using a given size lamp in some previous job that he had done. He admitted that the electrical contractors as a class were sadly deficient in a definite knowledge of illumination. This is the type of man that the general public looks to to solve their lighting problems. The

fault is not his entirely but to a great extent ours, as we have been exchanging views and reading papers to each other with the result that our research and experience does not penetrate beyond this circle. We have attempted to appeal to the electrical contractors and to other lighting interests, with the idea of arousing an interest in better illumination, and I am sorry to say that the results are not at all encouraging. It would seem that our method of propaganda is wrong. We must go out in the field and meet them on their own ground and not expect them to come to us. This problem is purely one of collaboration and I believe that by persistent efforts that we can not only arouse an interest in the subject of better illumination but can be the means of conveying to the electrical contractors information which will be of great service to them in their work.

To show the lack of cooperation in the electrical industry, it was only a few years ago that the manufacturers of incandescent lamps and lighting reflectors did not work in harmony, so that when the Mazda C lamp was placed upon the market there was no reflector which would give proper results. In order to correct this fault a Committee of Reflector Manufacturers and Lamp Manufacturers was organized to design a proper type of reflector for Mazda C lamps and the result was the R. L. M. Standard now on the market. This shows that through collaboration results can be obtained.

The point I wish to bring out is that the architect is not a strong factor in the lighting situation, particularly when it comes to industrial buildings. This holds true in New York City and also elsewhere. You will find that in a building of industrial type, or a loft building, he will use his judgment as to the location of the lighting outlet, the selection of the fixtures being left to the tenant. On the other hand, if it is an industrial establishment, he will locate the outlet without any thought of layout of equipment, the kind of reflector or fixture to be used. That portion of the work goes to the electrical contractor as an extra on the wiring job. I have seen it work out hundreds of times in this manner, as I have tried to fit the fixtures to the spacing of the outlets. I think practice has shown that the architect has no really safe ideas on the illumination of industrial buildings.

G. H. STICKNEY: As a rule, large manufacturing establishments are much better lighted than the smaller ones. This undoubtedly is due to the fact that the large manufacturer is in a position to secure better advice.

Unquestionably, good lighting is fully as important to small manufacturers, and since this class is so numerous, he makes up a large percentage of the industrial light users. The real question is, how can he be helped more effectively than at present.

The Eastman figures, presented at the Chicago convention, showed that nearly 24 per cent. of the manufacturers look to the electrical contractors or retailers for advice and as many more look to other distributors of lamps and equipment, while only about 15 per cent. look to consulting engineers and architects. If these distributing agencies are to continue prescribing lighting methods and equipment, every effort should be directed toward helping them give the best possible recommendations.

It should be recognized that the contractor faces a difficult situation. There is a tendency, on the part of buyers, to induce a severe competition between contractors, with the understanding that the low bid secures the business. There are bound to be individuals who will find ways of cutting down the cost—usually by providing a less effective and often an inefficient installation, and the competent contractor who wishes to make a good job, must meet such competition. Too often he succumbs and sells what is cheapest rather than what is best for the customer. If he could convince his prospective customer of the real facts as to the customer's interest, he would not need to worry about the lower bid made by his competitor.

An incident illustrating some of the unfortunate results of poor lighting advice received from the industry, came to my attention not very long ago. A central station lighting company, in a large city, had, after considerable effort, persuaded a large manufacturing company to abandon their power plant for central station service. The manufacturer desired to revamp his lighting system, and employed a leading contractor, recommended by the central station. The lighting which was planned by the contractor, soon proved unsatisfactory. At the solicitation of the central station, I had a survey made which revealed the

fact that the contractor's recommendation was about ten years behind the times, unshaded lamps and drop cords having been provided throughout.

Nothing short of a radical rearrangement of circuits would provide a suitable and economical installation. This obviously, would involve a considerable waste of the money spent for the installation. The manufacturer had good reason to feel that he had not received a good proposition from the lighting industry. So besides suffering a considerable loss both in manufacturing efficiency and electrical construction, he must have lost confidence in the industry, including the company from whom he was buying current. Further, a rather delicate situation arose between the central station, the contractor and the lamp manufacturer, which was keenly felt by the last named, because the contractor in question, was distributing his product. The lamp manufacturer had for years been trying to teach good lighting practice but had failed to get it applied by this contractor.

Observation indicates that there are still many poor lighting installations being made, so that it is very important to the lighting industry that the message of the Illuminating Engineering Society reach the entire industry, so that the layman can be assured of good lighting advice.

A. L. POWELL: For the past six weeks or so, I have been spending most of my time addressing meetings of electrical contractors all the way from New York to Texas. I find them to be vitally interested in the question of lighting for the industrial plant. They are interested because they have begun to realize that it will yield many practical benefits to them. More outlets will be required, a higher quality of equipment installed, and a more generally satisfactory job result. I believe that in general, they are sincerely trying to do the right thing and that it is up to us as illuminating engineers who have the talking points and the methods of industrial lighting at the tips of our tongues, so to speak, to use every opportunity to get these across to the contractor.

There are loft buildings about the city which are used as factories and for other industrial purposes. Their lighting demands are likely to vary. The local contractors are much in-

terested in the proposition of providing wiring which will adequately and properly take care of the future demands for these buildings. There is a great deal to be done in this local territory.

We all realize the physical impossibility of the state inspection force thoroughly covering the entire territory and it is not their fault that much poor lighting exists. On the other hand, we must recognize conditions as they are. Just this afternoon I rode on the Second Avenue elevated from the Brooklyn Bridge to 23rd Street and while not particularly thinking of the question of lighting when I started on this trip, I chanced to glance out of the window and noted the total inadequacy of lighting in the first few loft buildings and small factories which I passed. I then began to make mental notes of conditions as I sped past a very diversified collection of buildings, and frankly speaking, did not notice one installation which would pass the New York State code.

There were 200-watt Mazda C lamps without reflectors hanging a few inches in front of a workman's eyes. In some instances, tissue paper was hung around a lamp to partially shade the eye, a very probable fire hazard. A few low candle power lamps were used to light several hundred square feet and similar installations.

It is extremely important for us, therefore, to get at the root of the situation and educate the man who is installing the equipment, that is, the electrical contractor. We have a mighty big proposition on our hands for as a society we can only reach these smaller jobs through a purely educational propaganda.

R. H. Maurer: Mr. Powell spoke of some of the lofts and factories in New York being lighted by flickering open flame gas burners. The gas companies throughout the country and the American Gas Association are greatly interested in the elimination of the old open flame burners. The gas companies are also interested in the various codes being formed. These codes, as I understand them, are for illumination in general and no particular form of illuminant. Various new burners are in the market to take the place of the open flame burner and many companies are making special offers to consumers who

will discard the open flame burner and replace it with the modern mantle unit; and I would say that it is hoped that in a short time the open flame burner will be eliminated.

The gas companies in New York are doing good work along the line of educating the public in the new methods of correct illumination; lectures are given to salesmen who come in contact with the public, and only the best mantles, burners and accessories are now adopted after rigid tests. We think that this work will go far in helping to familiarize the public with the great benefits to be derived from good illumination, and we hope that in a few years there will be no just reason for referring to gas illumination as the flickering open flame burner.

J. H. Vogt (In reply): As you no doubt are aware the New York State Industrial Commission has by authority of the legislature conferred upon it the enforcement of the labor laws relating to factories and mercantile establishments. It also has the police power of the state to put into effect those various laws. It has the legislative authority to make rules and regulations which shall be in effect as law. Now we realize that the Department is limited in enforcing those provisions of the law relating to lighting only as to safety. We, however, recommend, that greater intensities of light be provided than those established in the code.

We know there is a great deal of work to be done. We have already made a start. You can see that in the recapitulation of the work done by our department stated at the end of this paper.

Reference was made to the factory of the Triangle Waist Company in New York which, in 1911, appalled the country by the loss of life of some one hundred and fifty men and women, principally women, who were obliged to jump from the twentieth story to the street and were dashed to death. As a result of that, the state factory investigating commission investigated the conditions of factories and found that under the state labor law it was impossible to enforce the law as it should be, notable among which was the methods of exits, and without going into all of that there were some fifty or sixty sections added to the labor law some twelve or fifteen of which relate to the proper lighting of factories. In so far as the state industrial commission has conferred upon it the power of making rules and regulations which shall be in

effect as law, a committee was appointed relating to the proper lighting of factories of which our very able chairman, Mr. Marks, was a member, and gave us some very valuable information. We are working together on that now and I think if we can co-operate with your Society, which we certainly desire to do, with our legislative powers and our police powers of the state we will be able to bring about, by force, if necessary, through court action, the proper lighting of factories, which will at least materially assist in bettering conditions for the working people. Now the courts demand to know what standards exist for different things. For instance, if an order is issued by the Department by an inspector to eliminate the heat from a factory the courts immediately want to know what is the standard of temperature, or in a laundry for instance, if steam is present with a high relative humidity, the courts immediately want to know what our standard for relative humidity is. The same thing has come up for lighting.

Before starting in to make this code I was called upon, being the Director of the Division of Industrial Hygiene, to conduct a series of tests in factories irrespective of what anybody else said, and I immediately set to work three of my best men who were college trained and who were practical inspectors, having been with the Department, and knowing the law thoroughly, to make a series of tests of conditions in factories as they actually existed. They made them during the night, spending four or five months, during the months of December, January, February and March in factories in order to get the true readings or as near as we could get them so daylight would not interfere with the artificial illumination. During that time we made more than 18,000 tests. When the report was delivered with tabulations to the lighting committee and without being guided, I want to bring out this point particularly, without being guided or influenced by any other code the committee adopted the standards for roadways, storage spaces, stairways, passage-ways and aisles which agreed practically in their entirety with those standards set forth by the Illuminating Engineering Society. Now our code at the present time is divided really into two parts, that part which is mandatory and that part which does not become mandatory until July 1, 1920. It was originally stated to be July 1st, 1919, but if you have seen this code, and no doubt all of you have, there is

an invitation given to the manufacturers of the state, of which there are sixty-eight thousand and some seventy odd thousand mercantile establishments, inviting them to make tests and supply the code committee with the information as to the lighting conditions in their factories. Now, hearings will be held in accordance with the law before the code relating to the intensities of light becomes mandatory in 1920, at which the manufacturers can have their say, whether the quantity of light which we state in our proposed code which becomes mandatory on July 1, 1920, is all right or whether we are too high.

THE CHAIRMAN: The intensity requirements are mandatory now, aren't they?

MR. VOGT: Only in a general way, those relating to wash rooms and closets, enclosures, aisles, stairways, dressing rooms, elevator cars and elevator entrances.

We have not received from any manufacturer or from any society any thing relating to the conditions of the factories which the proposed code invites. Now, with regard to the shading of lamps I must say that I was greatly interested in the paper relating to glare. If we could have something that would show us where glare begins and where glare ceases I think we would be able to go a great deal farther than we can now.

I have in mind a case in which a man connected with the New York State Department of Health whose eyesight was failing attributed it to the condition of the light in the Department of Health offices, and through a resolution of one of our senators a call was made on the State Industrial Commission to conduct an investigation of the sanitary conditions and general conditions relating to the public buildings at Albany in which the state employes were housed. There are some sixteen buildings, including the capitol, in which 2500 men and women were employed, and it was found that 80 per cent. of those engaged in work in the Capitol and in the buildings connected with the New York State Capitol wore glasses. They all more or less said they suffered with eye trouble. In the capitol buildings there were many unprotected lights and in the New York State Hygienic Laboratory there were lights of 200 wattage capacity placed directly in front

of men's eyes, and if those buildings had been factories, and were subject to the labor law there would have been over three hundred orders issued on those buildings to correct the conditions to make them up to the labor law standard.

I might refer here to a recent case brought before a magistrate in the City of New York of a manufacturer failing to shade the lights properly, to protect the lights from glare. The manufacturer had placed yellow paper around the incandescent globes and the magistrate decided that that was a reasonable compliance with the law irrespective of whether it presented a serious fire hazard or not, that that was a different matter. So you can see what we are up against when we are up against the courts.

Another thing that might be of interest to you is that we educate our inspectors. We have over 900 rules for the inspectors' attention, relative to factory and mercantile inspection, and also hundreds of sections and paragraphs of the law. Every month or two the inspectors are brought together in the various supervising districts, New York, Utica, Rochester and Buffalo, and are given talks and shown slides of good conditions in contradistinction to that of poor conditions and notable among which we have had a number of lectures on light and illumination.

There remains a great deal of work in bringing about conditions to give the maximum protection that the law allows us to enforce. We go further than that and we think that by this authority that the department has in causing these things to be of a mandatory character to be enforced by court action, if necessary, that in the course of a few years we will be on record, as the state which brought about better conditions for the working people in factories.

REPORT OF COMMITTEE ON AUTOMOBILE HEAD-LIGHTING SPECIFICATIONS,* 1918-19.

Supplementing the work done last year in preparing specifications for laboratory tests of automobile headlighting devices, this Committee has collected further information on the subject and has revised and improved the specifications which it originally issued.

Since the issuance of the 1917-18 report a three-day joint meeting (January 8, 9 and 10, 1919) has been held, for the purpose of securing material to aid in the preparation of a model headlight law. This meeting consisted of the Committee on Lighting Legislation with this Committee and a number of device manufacturers, traffic officials, representatives of the Society of Automotive Engineers and of the American Automobile Association, and other interested persons for the purpose of reviewing the situation and clarifying the problem. Many diverse opinions were expressed by those present and while no definite conclusions were reached, the information secured greatly strengthened the views of this Committee in regard to the underlying principles to be embodied in State specifications for approval of devices.

As a result this Committee drafted a model headlight law which was submitted to the Committee on Lighting Legislation. The latter Committee made such changes and additions as seemed requisite, but did not alter the technical details for which this Committee is responsible.

This model law appeared in the TRANSACTIONS for March, 1919, p. 101.

In the preparation of the original specifications submitted to New York State this Committee by unanimous expression preferred more rigid requirements than those given. However, they realized the impracticability of insisting upon these requirements at that time.

It was hoped, however, that after the enforcement of the specifications for a period of one year, more rigid specifications might be practicable.

* Report prepared for presentation before the Thirteenth Annual Convention of the Illuminating Engineering Society, Oct. 20 to 23, 1919, Chicago, Ill.

Hence after the joint meeting referred to above the Committee tentatively adopted for future use in connection with the model headlight law a somewhat altered and strengthened set of specifications for acceptability tests of headlights. The gist of these propositions is contained in the following set of test positions and candlepower limitations.

Position 1.—Some point between road level and a point on a level with the lamps in the axis of the car not less than 4,800 candlepower.

Position 2.—In the axis of the car 60 in. above the roadway at 100 ft. not more than 2,400 candlepower.

Position 3.—60 in. above the roadway, 7 ft. to the left of the axis of the car at 100 ft. not more than 800 candlepower.

Position 4.—At 100 ft. at some point between road level and a point on a level with the lamps and 7 ft. to the right of the axis of the car not less than 1,200 candlepower.

The Lighting Subdivision of the Standards Committee of the Society of Automotive Engineers arranged some tests for the purpose of investigating the above values. As a result of these preliminary studies the members of the Committee who participated in the tests were of the opinion that these limits substantially met with the requirements.

Therefore, when the Commissioner of Motor Vehicles of the State of Connecticut requested the Committee to submit to him a set of specifications, an opportunity was offered to make a review of the New York specifications so as to incorporate the above provisions in accordance with the latest ideas of the Committee.

The specifications incorporating the above provisions and submitted to the Commissioner of Motor Vehicles of the State of Connecticut require four times as much light between horizontal and the roadway at 200 ft. as do the specifications prepared for the State of New York. They also require as much illumination between horizontal and road level at 100 ft. and 7 ft. to the right of the axis of the car, as do the earlier specifications. The specifications at the "glare-points" are the same as those of New York. In addition to these requirements no device is to receive approval which when adjusted in accordance with printed instruc-

tions accompanying same, can not satisfactorily comply with the specifications using vacuum lamps of fifteen mean spherical candlepower and gas-filled lamps of 21 mean spherical candlepower. At the present writing these specifications have not been officially adopted.

Within the past month the Commissioner of Highways of Pennsylvania through the Registrar of Motor Vehicles has made application to this Committee for specifications which might be used in Pennsylvania. Both sets of specifications were, therefore, forwarded with a complete explanation of their differences, and of the facts leading to their preparation. The Commissioner has used these specifications as models and has prepared a new set representing a compromise. The officials of Pennsylvania believe as did those of New York State, that too rigid requirements at first would not be advisable. Therefore, they specified the same values as New York, with the addition of a requirement of (800 candlepower minimum) 7 ft. to the right of the axis of the car between horizontal and the roadway at 100 ft. Also each device manufactured and marketed must be accompanied with adequate instruction as to installation.

Both Connecticut and Pennsylvania have established the "Inspector System" in which they supply their inspectors with a portable photometer so that actual tests will be carried on on the road. The mere approval of a device does not mean its compliance as installed upon a car, as the device must not only be approved but must be properly installed and the lamp properly focused.

It is interesting to note that the State of California has incorporated in its revised motor vehicle law the I. E. S. specifications as furnished New York State with only a few minor alterations.

DISCUSSION.

Louis Bell: It is certainly very gratifying to see the committee really making specifications which are going to be taken up and which will prove effective. I want to speak in special appreciation of the suggestion of testing with a standard candlepower lamp because it is an unfortunate fact that we have no limit on the amount of light that a man is at liberty to put into his lamp. The specification even in its rigid form

can be complied with by extremely rudimentary devices. A 36 candlepower lamp and good black paint will technically pass the New York specification, as it now stands, with flying colors, and with the apparent advantage of being able to use a very high candlepower lamp. It is not stated to the public that you get the same light that you would with a properly adjusted small lamp but the bold facts are there. So it seems to me in making these tests, official tests, the idea of testing with a standard lamp is a most admirable one which ought to be carried out, and the test, I think, should not be coupled with the use of the maximum candlepower that can be squeezed through and get by. I have seen many instances of that, but with the change in the specifications and with the use of lamps of standard size for testing, it seems to me we are going to get a very good class of headlights. There are a fair number of them now that have been doing good work, and by those changes in the specifications I think the permitted devices will be brought down to those which are really excellent.

J. R. Cravath: I think we are certainly to be congratulated on the work of this headlight specification committee. Prior to the appointment of this committee two years ago we had nothing much but theory to go by as to what headlight requirements were satisfactory from a glare standpoint and what were not, but the result of the practical tests that this committee has been carrying out is such that we now have a fairly definite idea, and that is necessarily the beginning of any work to straighten out our much tangled headlight situation. In fact, this whole matter is a matter of education. First, we have to educate ourselves as to what the proper specifications are. Next, we have to educate the manufacturers as to what we have found out, and lastly, also the public garage mechanics and the users. That process of education has apparently gone much farther in some parts of the country than in others. I think one of the most important steps of progress that is indicated in this report is contained in the next to the last paragraph which calls attention to the fact that Connecticut and Pennsylvania have established an inspector system by which they supply their inspectors with a portable photometer so that actual tests

will be carried out on the road. It would seem to me, from my study of this matter for several years, that until we get some system of testing cars as they are actually used, that we are not going to get very far in the enforcement of any headlighting regulations. To be sure, it is a very important step to weed out the devices which have absolutely no merit by a system of approval certificates, such as New York and some other states have adopted, providing for laboratory tests to tell which devices can be satisfactorily used; but that is only going about 10 per cent. of the way to complete success. The other 90 per cent. of the way consists in getting the devices applied properly and kept in proper shape. Unfortunately, an automobile headlight is even more likely to get out of adjustment than the carburetor. The carburetor may stay adjusted for a number of months or years, but the headlight lamp may get out of adjustment almost any time by being hit in a collision, or from having the lamp filament sag or by renewal of lamps for some cause unknown to the driver. For these reasons I believe the inspector system is necessary, and I believe, also that with that will come the establishment of what you might call test stations where drivers can find out whether their lamps are adjusted properly, in fact, garages will probably begin to make that a part of their equipment as they have begun to do on the Pacific Coast. It need not be very complicated. When that is done we will be much nearer satisfactory headlight conditions than we are now.

H. P. Gage: This discussion is particularly interesting to me as I have been devoting considerable effort along this line recently. It is a matter on which an enormous amount of education is required, and a matter which a few of us think is really very simple, but to the people who are most interested it is not a simple matter. There are three classes of people particularly interested. There are the manufacturers who equip their automobiles with devices which are intended to produce road illumination. Sometimes they do, and sometimes they do not. There are the people who deal with the legislation, and there is the public who use them. Now, to all three classes the matter of illumination by automobile headlights is somewhat of a mystery. We recently had occasion to examine very carefully

the lamps as used by two different manufacturers of very high grade automobiles. We found in one case a beautiful appearing reflector which had the common defect of flaring out at the edge. It was a parabolic section part way and then it flared out like a vase. In the other one which we examined the whole surface was more or less corrugated so that it gave a beautiful diffusing result. The manufacturers of those cars thought they were getting good quality material. Of course, there are other manufacturers of cars who know that they are getting a low priced product and do not particularly care. I will say for a number of automobile manufacturers, if it is pointed out to them how to get a better quality they are perfectly willing to pay the cost.

Then there are the law makers. The best thing for their information are these reports of the committees. In many cases the legislators have shown their willingness to adopt many of the suggestions of this Society. Sometimes the law places the matter in the hands of a commission which has the power and is willing to adopt reasonable regulations. It would seem to me that if this report could be printed for distribution, perhaps giving a little bit more detail to the explanation of the repositions measured, and if we could have printed with the report the illustrations which were shown in the lantern slides, it would make further progress much easier.

Lastly comes the poor public which knows nothing about optics, and the chances are that the man who does not know how to adjust his own lamps goes to a garage where they know less about the matter than he does. It is really a decidedly unfortunate situation and I hope that before long the machinery can be completed to properly install lamps in the individual cars and to adjust them afterwards whenever necessary. Success will not follow the appointment of a lot of men to go around with little portable photometers to hold up everybody who has not got his lights in adjustment, until it is possible to suggest to the people arrested some possible method of getting their lights in adjustment, or some place that they can go and pay somebody to get their lights fixed if they do not know how to do it themselves.

G. B. NICHOLS: After listening to the article as presented, I am very much impressed with the way that this whole subject has been handled, carrying the specifications for Automobile Headlights almost to perfection. At the time the specifications for automobile headlights were prepared for New York State, it was my privilege to sit in with the committee at their various meetings and to see what time and careful consideration was given to each phase of the work. One of the last speakers spoke of the varying industries that were interested in this item. He falied to mention the main one, namely, the commercial side, or the manufacture of lenses. At the present time, the cost of manufacturing the different types of lenses varies to a great extent and, on this account, there is a demand by the cheaper manufacturers for the various State specifications to be written in such form that they will include their lens, even if the lens has not the proper merits to be allowed on the road. A great deal of this comes around through a misunderstanding on the part of the manufacturers or a deliberate propaganda to dispose of their product. It was surprising at the various conferences held on this subject the number of varying interests that were present and how unscientific the discussions were, completely clouding the issue. New York State finally adopted a form of specification and certain lenses were approved. Whether this is a wise choice remains to be seen. The facts are there are still on the road lenses that endanger the public life. Two years have gone by and there appears to be no solution of this problem. Undoubtedly, future legislation will have to be made on this subject, but until the public are more urgent in their demands on the legislature, I very much doubt the success of the revision of the law, until more facts are established.

JOHN A. HOEVELER: We are doing something on the headlight situation in Wisconsin. The legislature at the last session passed a law stating in general terms what the motorist must do in the way of providing a light ahead of his car and avoiding glare, and the industrial commission has been charged with the duty of establishing standards giving the details for carrying out this general law. There is one feature of the law which is different, I believe, from any other. There is a statement

to the effect that the use of headlights or lights on an automobile which do not comply with the standards set by the industrial commission shall be prima facia evidence of unsafe practice in the use of the highways. In case of a personal injury suit, if it is shown that the person who caused the damage had lights which did not comply with the law, and that this failure to have proper lights was the cause of the accident, the court must assess damages. The industrial commission has an advisory committee at work now considering this question and I am very glad to be here to get this committee report because we need help of this kind from men who can speak with authority on the subject.

C. O. Bond: I saw this morning on the train somewhere between here and Gary, a fine stretch of level road paralleling the track. Suddenly it turned at right angles and there dead ahead was a very fine place for a sign, and a sign was there advertising somebody's tires. Now it occurred to me, that there was your testing station all laid out for you. This sign or test board should be at the end of a level stretch. A marker could be put off 200 feet, showing the standard testing range, your driver trains his mounted lens on the painted silhouette ahead, on the test board to indicate a form which his illumination should fill. If his beam fell out of the limits he would know he was out of adjustment and in which direction. Each car would carry two simple sights, one over the radiator funnel and the other in the center of his wind shield to indicate correct adjustment of car towards the test object. I might go further with the suggestion and prescribe that the Test Silhouette which is to be illuminated to different intensities in its several parts, shall have those parts painted in neutral colors, each of inverse absorption to its expected illumination. Thus a correct lens would show a uniformly lighted silhouette. That might be worked out. I assume that the lamp at installation time will have the maximum brilliancy permissible. It is not thinkable that after the lamp has been in use for some time that it will give more light than at the beginning, so that errors will be on the side of safety.

Ward Harrison: Why it is that the majority of the cars which are still being used with clear glass in their lamps, in lieu of

lenses, have their headlights pointed straight ahead instead of turning them down through a small angle so as to more nearly comply with specifications, and why it is that all lenses are designed to be used with headlight pointing straight ahead when the simpler method would seem to be to point the headlight at about the angle you wish it and then use a simple lens to spread the light sideways.

L. C. PORTER: I believe that the committee has made a big step towards ultimate satisfaction in the automobile headlight game. I also believe that eventually we should have and probably shall have federal legislation on the matter. It has already been brought about in connection with locomotive headlights and I see no reason why it should not be applied also to automobile headlights, although the question of how to do it is probably a pretty complicated one. I think perhaps the best way to go at it is the way the committee has started, that is to draw up sample specifications and submit them to the various states as a model. I might perhaps suggest that it would be advantageous to point out the desirability of having uniform legislation throughout the different states, particularly through the East. Take for instance, in the state of New Jersey; probably every car in the state of New Jersey goes more or less frequently into New York or Pennsylvania, New York cars go into Connecticut, and so forth and so on. There is every reason for having uniform regulations regarding headlights in the different states.

I believe it is a good move to require the manufacturers of headlighting devices to distribute literature instructing the purchaser as to how to operate the device to get the most satisfactory results out of it. I think this can be carried a little further. I think we should congratulate California on the little pamphlet which the Motor Vehicle Department has published, covering general instructions for focusing headlights and showing photographs of properly focused beams and improperly focused beams. Coming from the Motor Vehicle Department of the state it probably will receive more attention than coming from the machine and lamp manufacturers, as a good many purchasers are prone to look at such literature as simply advertising ing matter and not take the time to read it.

Another point brought out is the question of the shape of the light source, and the proper focusing of the lamp. In incandescent lamp manufacture it is not practical to make one lamp the exact duplicate of another. You can't make a lamp as you can a piece of steel and machine it down to an accuracy of a thousandth of an inch. There must necessarily be some variations in the light sources. They are made of pieces of glass put together in molten condition. The filament operates from a very high temperature down to a cold temperature and, as was pointed out, is apt to sag slightly. Those things must be taken into consideration in connection with the use of glare reducing devices. I am glad to state that the lamp manufacturers are co-operating closely with the manufacturers of lenses and endeavoring to get together reasonable specifications and reasonable limits which can be applied.

There was recently brought to my attention a case where a manufacturer of one of the well known automobiles had a designing engineer from a well known optical company produce a glare reducing lens. This engineer told the said manufacturer that the best results would be obtained when the plane of the lamp filament was horizontal, which was true, pertaining specifically to the Mazda C type of lamp. The automobile manufacturer went a little further and specified to the lamp companies that the plane of the filament must be absolutely at right angles to the pins on the base, then they set their sockets so that the pins would be vertical without any adjustment whatsoever. That is entirely impractical as a lamp specification. It is not practical to manufacture lamps where the plane of the filament will be absolutely at right angles to the pins on the base of the lamp. Considerable effort, time and expense had to be put into convincing the automobile manufacturer that certain leeway was necessary in the lamp. I think we have come together to a point where they will allow reasonable variations. In the light center length of the lamp, for example, the present variations which are acceptable to the Society of Automotive Engineers are plus or minus 3/32 of an inch, that is, the distance between the center of the filament and the nearest point of the pins on the base, no part of the filament shall be more than 5/64 of an inch from the axis of the lamps. These specifications should be further supplemented with a leeway in regard to the plane of the filament in relation to the

pins on the base. Present manufacturing specifications call for a tolerance of plus or minus thirty degrees. I believe this is a little greater than necessary. The different lamp manufacturers are working to narrow these specifications. The general tendency in the Mazda C type of headlight lamp is to produce a more highly concentrated filament and a filament which will be more nearly symmetrical as to length and width. This will give a more nearly uniform beam and will do away with considerable of the trouble which some of you have experienced in focusing the Mazda C type of headlight lamps.

A. H. Ford (Communicated): When a committee of a technical society draws up a model law covering any phase of the technical work of the Society, it is to be expected that the technical part of the law will be clear and definite; so as to allow of one interpretation only. The presentation of a model law leaving the technical clauses indefinite is a confession of partial failure of the committee. The model law published in March 1919 is deficient in the manner mentioned and therefore the supplementary report of the committee, remedying the deficiency, is to be commended. There are some points in which the report is still indefinite and these should be made clear before the report is given general circulation.

Equivalent candlepower measurements of a light beam depend on the distance of the photometer screen from the light source. The distance from the light source at which measurements are made should therefore be specified in all cases. The apparent candlepowers given in the report are limits, but are not so stated. The writer suggests that Section 6 of the model headlight law be changed so as to read as follows:

Section 6.—Headlamps so constructed and adjusted so as to give the apparent candlepower mentioned, in the directions mentioned in this section; shall be considered as complying with Sections 1, 2 and 3 of this act. All tests shall be made with the test plane of the photometer vertical to the axis of the car and at a distance of 100 feet from the headlamps; while the car is without load and standing on a level road. Automobiles shall have both headlamps in operation during the test. The test shall be made with the photometer in the following positions.

Position 1.—The center of the test plane shall be located in the vertical plane through the axis of the car and between one and three feet from the road. The apparent luminous intensity, in the direction of the test plane, shall be not less than 4800 candlepower.

Position 2.—The center of the test plane shall be located in the vertical plane through the axis of the car and five feet above the road. The apparent luminous intensity, in the direction of the test plane, shall be not more than 2,400 candlepower.

Position 3.—The center of the test plane shall be located seven feet to the left of the vertical plane through the axis of the car and five feet above the roadway. The apparent luminous intensity, in the direction of the test plane, shall be not more than 800 candlepower.

Position 4.—The center of the test plane shall be located seven feet to the right of the vertical plane thru the axis of the car and between one and three feet from the road. The apparent luminous intensity, in the direction of the test plane, shall be not less than 1200 candlepower.

Clayton H. Sharp (Communicated): Mr. Ford states that the presentation of a model law leaving the technical clauses indefinite is a confession of partial failure of the Committee. Speaking for the Committee, I must deprecate this statement. The technical details were intentionally omitted from the law on the theory that they belong properly in the specifications, which specifications should be adopted as an administrative measure by the proper official. Hence in due sequence the Committee has prepared such specifications.

The further criticism which Mr. Ford makes and which is constructive inasmuch as it embodies positive suggestions, is evidently directed against the statement contained in the report of the Committee which is there given as embodying the gist of the propositions, and which does not state even approximately the wording of the actual specifications. The actual specifications themselves have not been reported verbatim to the Society.

GENERAL SECRETARY'S REPORT FOR THE FISCAL YEAR 1918-1919.*

Clarence L. Law.

The work of the Society for the past year has progressed without abatement and the same interest and enthusiasm has been displayed by all committeemen as has been evidenced in the past. The Society's work under the past administration started with the close of the World War, under conditions still abnormal but with the prospects of an early return to a pre-war state uninfluenced by the handicap of excitement and pressure.

Council.

The Council has met regularly each month with the exception of the summer months when the Executive Committee met in July and September to take care of necessary business. The attendance of the officers of the Society at Council meetings has been as good as could be expected in view of the fact that some are located at a considerable distance from headquarters. With the exception of Messrs. C. A. Luther, P. G. Nutting, and James J. Kirk, all officers have been at either one or more meetings, some being at each meeting.

Membership.

The status of the membership at the present time can be judged best by figures presented in the report of the Committee on Membership.

Unfortunately, the statistics which are presented show some decrease in the membership of the Society. It is believed that this is not due to any general lack of interest, but at least in part to the fact that some men who returned from military service and who had been retained last year on the membership roll with their dues remitted, have gone into other lines of activity and have accordingly dropped from the I. E. S. membership.

* Reprint prepared for presentation before the Thirteenth Annual Convention of the Illuminating Engieeering Society, Oct- 20-23, 1919, Chicago, Ill.

A comparison with last year's report shows that the number of members and associates who resigned is not as great this year. The number dropped this year, however, for non-payment of dues is somewhat larger than the previous year, and the number of members and associates elected has been 77 this year as against 89 last year. There has also been a considerable loss due to the death of members and associates, 16 having died in 1918-19 as against 9 in 1917-18. The number of transfers from associate to member have been lamentably small in this last year, only 6 tranfers being effected as against 17 in the year before. The number of reinstatements is 14 as against 12 for last year.

The Committee on Membership deserves a considerable amount of credit for its work. Though it does not show a gain in the number of members, the Committee is responsible for the new members and for several letters which spread the propaganda of the Society to a great number of those in the lighting industry, which may bear fruit at some later date.

Sustaining Membership.

The Sustaining Membership Commmittee conducted a campaign for new sustaining members, and while but 1 application was received in direct response to its efforts, it was felt by the committee that this was largely due to the conditions existing since the signing of the armistice. A good foundation has been laid for a more fruitful campaign during the new administration. The present number of sustaining members is 64 as against 67 at the beginning of the administration.

Sections.

The activities of the Sections have continued under the direction of the local Boards of Managers. The following table will give some idea of the direct results.

	Chicago	New England	New York	Philadelphia
No. of meetings	6	5	5	6
No. of papers	5	6	12	7
Expenses	$327.82	$112.08	$412.07	$366.20
Members	129	88	391	265
Cost per member for Section Expense	$2.54	$1.27	$1.05	$1.38

Local Representatives.

The Local Representatives of the Society now number 39, representing 21 different states. We are represented also in Canada and South Africa.

Papers.

The Committee on Papers has done excellent work during the year just passed. They have collected for presentation a total of 48 papers. Of this number 46 were printed in the Transactions. Papers were presented as follows:

Chicago Section	5
New England Section	6
New York Section	12
Philadelphia Section	7
General Meeting	1
1919 Convention	24
	55
Less multiple presentation	7
Total number presented	48

For various reasons, it has fallen on the Chairman of this committee to make a considerable number of decisions and take action as to matters of editing. The chairmanship of the Committee on Papers necessarily involves considerable amount of personal labor, especially during the period of preparation of the Convention program. The Chairman, therefore, wishes to bespeak for his sucessor an arrangement which will minimize the detail requiring his attention.

The Committee is composed of busy men, and at times a few of them have been a little slow in answering inquiries from the Chairman. On the whole, however, the Chairman has had splendid cooperation from the entire Committee. He wishes, therefore, to take this opportunity to express his appreciation. The Committee as a whole desires to express its appreciation of the commercial support extended by the officers, authors, members, and especially to the General Secretary's Office.

Finances.

The Society's finances at the expiration of the administration are in a very staple condition. The budget prepared at the begin-

ning of the fiscal year has not been exceeded. This is the result of a very careful supervision conducted by the Committee on Finance. The monthly statements prepared by the General Office were carefully scrutinized by the Committee and any indication of excessive expenditures on the part of the General Office or any Sections or Committees were immediately curtailed. The Auditor's report called for under the Constitution of the Society is appended hereto, including a statement of receipts and expenditures for the past year.

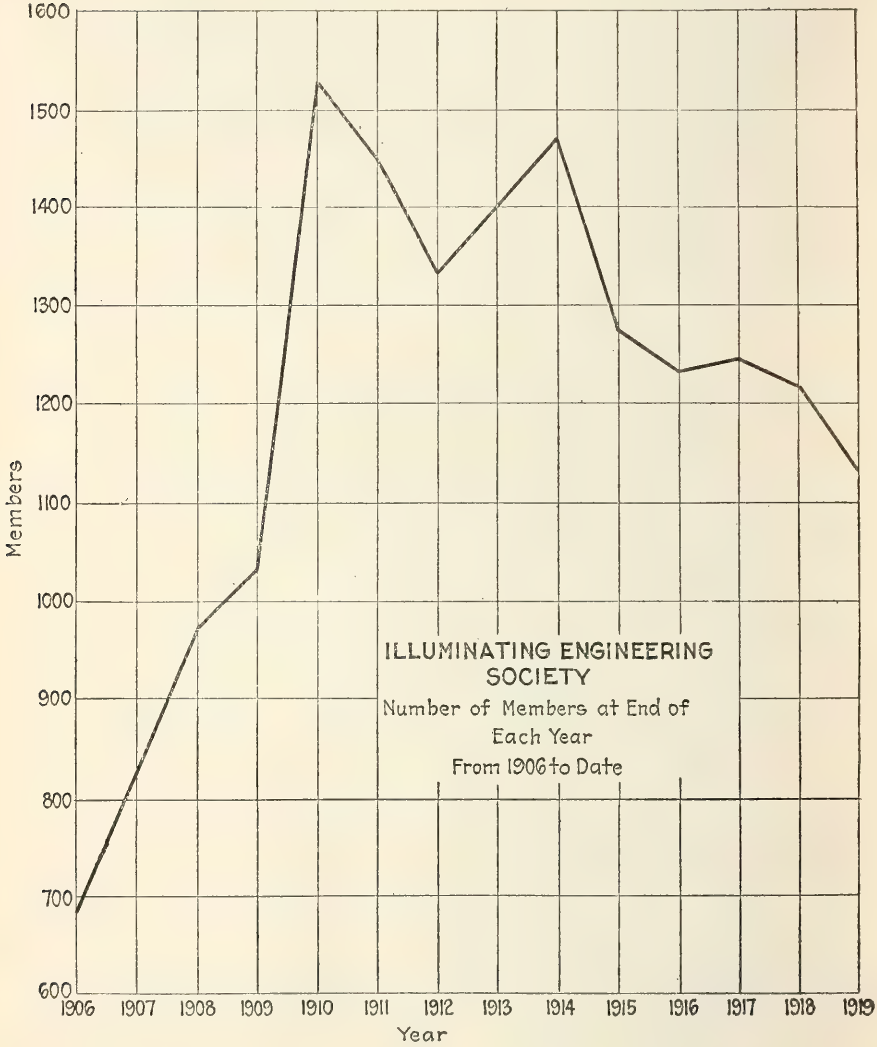
Your Committees' reports are too voluminous to include in this brief statement of the Society's work for the year. All show the results of a year's progress in the science and art of illumination.

Summary of Membership for Fiscal Year 1918-1919
(As of October 1, 1919)

	Elected		Reinstated		Transferred		Resigned		Deceased		Dropped		Canceled		Total	
	M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A
Chicago	4	7	2	3	–	–	–	12	1	1	1	11	–	–	40	91
New England	3	–	1	1	–	–	–	8	1	2	1	6	–	–	28	61
New York	7	23	1	2	3	3	5	17	1	4	10	18	–	–	141	258
Philadelphia	1	3	–	3	1	1	2	21	1	1	3	16	–	–	65	190
Pittsburgh	1	9	–	1	1	1	1	6	1	–	2	8	–	–	38	53
Non-Section	3	19	–	–	1	1	4	7	–	–	1	8	–	1	37	147
	19	61	4	10	6	6	12	71	5	11	18	67	–	1	349	780
Total	80		14		12		83		16		85		1		1129	

Comparative Statement of Section Membership

October 1, 1918				October 1, 1919		
M	A	Total		M	A	Total
36	103	139	Chicago	40	91	131
26	74	100	New England	28	61	89
143	269	412	New York	141	258	399
72	233	305	Philadelphia	65	190	255
40	60	100	Pittsburgh	38	53	91
39	126	165	Non-Section	37	127	164
356	865	1221		349	780	1129


1600
1500
1400
1300
1200
1100
1000
900
800
700
600
Members
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
Year
ILLUMINATING ENGINEERING SOCIETY
Number of Members at End of Each Year From 1906 to Date

APPENDIX

October 15, 1919

ILLUMINATING ENGINEERING SOCIETY,
29 W. 39th Street,
New York, N. Y.

DEAR SIRS:—

In accordance with your instructions we have examined the books and accounts of the Illuminating Engineering Society for the twelve (12) months ended September 30, 1919.

The results of this examination are set forth in two exhibits, attached hereto, as follows:—

Exhibit "A"—Balance Sheet, September 30, 1919

Exhibit "B"—Earnings and Expenses, for the twelve months ended September 30, 1919

We certify that, in our opinion, the Balance Sheet is correct, that the Statement of Earnings and Expenses properly sets forth the results of the operations for the twelve months ended September 30, 1918, and that both are in agreement with the books.

Respectfully submitted,
W. J. STRUSS & Co.,
Certified Public Accountants

September 30, 1919

EXHIBIT "A"

Assets

Cash on Hand and in Bank		$3,943.43
Liberty Bonds		3,000.00
ACCOUNTS RECEIVABLE		
Advertising	$ 26.76	
Sustaining Members Dues	140.00	
Members Dues	25.00	
Fees	10.00	
Transactions	27.45	
Miscellaneous	12.80	
		242.01
Inventory—Badges, Primers, etc.		245.80
Furniture and Fixtures		642.55
		$8,073.79

Liabilities

Advance Dues		$ 65.25
Advance Fees		12.50
Reserve for Unpresented Items		875.00
Accounts Payable		1,280.34
Surplus—		
September 30, 1918	$5,123.64	
Adjustments Prior Period	43.12	
	$5,080.52	
Net Profit for the Twelve Months ended September 30, 1919	760.18	
Surplus September 30, 1919		$5,840.70
		$8,073.79

EXHIBIT "B"

Earnings

Members Dues	$3,316.00	
Associate Members Dues	3,735.00	
Sustaining Members Dues	3,960.00	
Initiation Fees	185.00	
Advertising Sales	944.55	
Transactions Sales	659.05	
Miscellaneous Sales	279.71	
Interest Earned	190.00	
Total		$13,269.31

Expenses

Transactions			$ 3,419.38
General Office—			
Salaries		$3,052.98	
Rent		1,301.04	
Printing and Stationery	$ 714.66		
Postage	473.41		
Telephone	199.96		
Miscellaneous	399.82		
		1,787.85	
			6,141.87

New York Section	400.02
Philadelphia Section	306.20
Chicago Section	327.82
New England Section	112.68
Committee Expense	350.53
Convention 1919	1,222.90
Miscellaneous	96.93
Depreciation Furniture and Fixtures	71.40
Total	$12,509.13
Excess of Earnings over Expenses	$ 700.18